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HEAD INJURIES

AND SOME OF THEIR COMPLICATIONS*

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THE post-bellum literature upon the subject of head injuries and their complications has been so voluminous and so comprehensive that a paper confined to the general classification and treatment of such injuries would under these circumstances seem hardly warranted. In two recent papers, Mock[1] and Coleman[2] have so wisely and sanely outlined the general management of these cases that their articles should be consulted by those desiring to inform themselves upon this aspect of the subject. What I have had in mind for consideration in this paper, therefore, is a brief picture of the various groups into which skull fractures naturally fall, together with a more extended and detailed story of certain individual cases, their treatment, complications and end-results so far as possible.

Patients who have suffered violence to their heads in one form or another may, as a rule, be put into one of the following categories:

Class I. Those who are conscious and rational, in whom the cerebral damage is probably slight, a clinical state which is usually spoken of as "concussion." This condition may or may not be associated with a skull fracture, and there is usually a brief period of loss of consciousness at the time of the accident. Such patients almost without exception do well if confined to bed for a period of one to two weeks, but of course should be kept under careful observation during the first forty-eight hours especially, in case pressure symptoms of a serious nature ensue. If headache or vomiting is troublesome magnesium sulphate by rectum is indicated or rarely one or more lumbar punctures. If a fracture is shown in the *x*-ray and it is linear, it may be disregarded entirely except as an indication to keep the patient relatively quiet for a somewhat longer period than when there has not been a fracture.

Class II. Those who show evidence of considerably more intracranial damage than is ordinarily implied by the term concussion, the head injury as a rule being associated with a demonstrable linear fracture of either the base or the vault. These are the patients who require extremely careful observation, the whole picture of pulse, respiration, blood pressure, spinal pressure and especially the state of consciousness being taken into account in deciding whether they should have merely dehydration, or dehydration plus lumbar punctures, or in occasional instances a decompression.

In the following case there was evidence of contre-coup cerebral damage but the

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treatment was non-operative and the subsequent story seems to have borne out the wisdom of this method.

Fig. 1. Case II, at time of discharge to illustrate linear scar of subtemporal decompression.

Case I. L. M. A., a boy of six, surgical No. 28583, was referred to the Peter Bent Brigham Hospital by Dr. S. A. Levine of Boston, on April 11, 1927.

Five or six hours before admission the child had been in a motor accident and was rendered unconscious. There were multiple lacerations of the scalp and face, the right pupil was larger than the left and there was apparently some weakness of the right arm and leg. There was likewise a bilaterally positive Babinski reaction. *X*-rays of the skull showed a linear fracture of the right frontal bone, close to the coronal suture, crossing the middle meningeal channel in the floor of the middle fossa.

The child was put under careful observation after his scalp and face lacerations were sutured. He showed no signs of shock, but remained unconscious. Lumbar puncture was performed and yielded 20 c.c. of pink, bloody fluid.

He remained practically unconscious for four days but would take nourishment during this time. His right face showed some weakness

Fig. 2. Case III, showing appearance at time of discharge.

as well as the right arm and leg as noted, evidently a contre-coup contusion as his fracture was on the right side.

He began to talk ten days after the injury, his right-sided weakness gradually cleared up, so that at the time of his discharge on May 2, 1927, he seemed quite normal in every way, including speech comprehension.

End-result (two years): His mother reported on May 6, 1929, that he had remained in excellent physical and mental condition and that he stood well in school although the youngest in his class.

If pressure symptoms persist and become serious a decompression occasionally may be advisable. The next case well exemplifies such a situation.

Case II. J. D., a boy fifteen years of age, surgical no. 25406, was referred by Dr. A. C. Freeman of Norwich, Conn., on December 16, 1925.

Two days before admission he had been knocked down by a motor and rendered unconscious. He was taken to the local hospital

FIG. 3. Case IV. *X*-ray showing crescentic fracture lines in left frontal region (preoperative).

FIG. 4. Case IV. Operative scar at time of discharge.

FIG. 5. Case V. *X*-ray showing lateral view of depressed fracture in left temporoparietal region (preoperative).

FIG. 6. Case V. Appearance of patient and of operative site at time of discharge.

where he began gradually to regain consciousness. I saw the boy at the Norwich Hospital on the night of December 15. He was extremely drowsy but would respond to simple requests. There was a boggy swelling over the occipital region. *X*-rays of the skull showed a fracture with some depression at this site and a linear fracture extending forward to the right temporal region.

FIG. 7. Case VI. *X*-ray illustrating huge depressed and fragmented area in left temporo-occipital region (preoperative).

FIG. 8. Case VI. Appearance of fracture area after operation. Two of largest fragments have been replaced and depressed lower edge re-elevated. Small white lines are silver clips used in hemostasis.

First Operation: 3 A.M., December 16. The depressed area was explored and excised. The dura was contused but not penetrated. Some bloody fluid was evacuated by a nick in the dura and 10 c.c. of clear fluid removed by a puncture of the ventricle. The child was given magnesium sulphate solution by rectum, but he remained drowsy and was therefore brought up to Boston on the evening of December 16. The next day there was apparent some weakness of the left face, arm and leg, and he remained extremely drowsy. It was thought that he might have a clot on the right side.

Second Operation: December 17. A right subtemporal decompression was performed through the usual linear incision in the right temporal region. A large amount of bloody subdural fluid was evacuated. The cortex was considerably contused but no clot was present. The dura was opened widely over the temporal lobe and the wound closed without drainage.

On December 20 the boy had a series of convulsions involving the left side of his body. This was the only such episode. On December 26 he was quite conscious and rational, with the strength of his left side much improved. He was discharged January 6, 1925, apparently quite well in every way. (Fig. 1.)

End-result (two years): February 10, 1928. He went back to school a few weeks after his return home in January 1925, and got along very well. In the autumn of 1927 he entered college and has been entirely free of any symptoms. He has never had convulsions since the single series in the hospital.

Class III. Those who are profoundly unconscious or even moribund when they come under observation. Such patients have stertorous breathing, either a feeble or markedly bounding pressure pulse according to how far shock is advanced, sweating, restlessness, and all evidences of fatal cerebral damage. The face and scalp are as a rule highly contused and lacerated, the eyelids closed with ecchymotic edema and there is frequently bleeding from one or all cranial orifices. X-rays of the skull are likely to show a so-called bursting fracture or fractures, and

FIG. 9. Case VII. *X*-ray showing appearance of fragmented area before operation with area of bone defect in its center.

FIG. 10. Case VIII. *X*-ray before operation showing long linear fracture with crescentic depressed fracture at its posterior end.

FIG. 11. Case VIII. Appearance of patient and scar at time of discharge.

FIG. 12. Case IX. Preoperative *x*-ray showing fragmented bullet and loose indriven bone pieces around small wound of entrance.

lumbar puncture if it is performed yields fluid which is almost wholly blood. Little if anything can be done for these patients

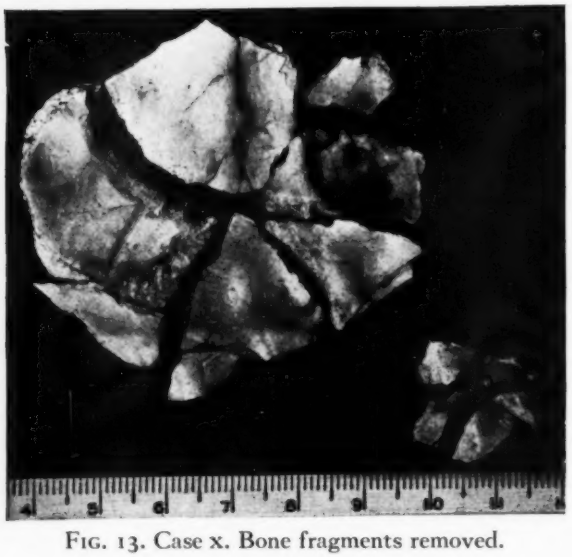

Fig. 13. Case x. Bone fragments removed.

although the usual measures for combatting shock should be instituted with perhaps occasional small doses of morphia. In years past we have been led rarely into performing a decompression in the faint hope of helping such a condition, but I do not recall a single instance of survival. It is my feeling that an operation is useless, even harmful in this type of case.

Class iv. Those who, either from their history or while under observation present the typical syndrome of an extradural clot from meningeal hemorrhage. In these patients the commonest story is that they have been rendered unconscious for a brief period and after regaining consciousness have relapsed gradually into a state of great drowsiness or actual coma. The interval of lucidity may vary from an hour or two to a couple of days, though rarely longer, and I have known a patient to have several episodes of alternating consciousness and coma over the course of a week. Skull plates almost invariably show a linear fracture crossing the meningeal channel in the temporal fossa. As soon as the condition is recognized a subtemporal decompression should be performed by a linear incision through the temporal muscle. The clot is often an inch in thickness and may be spooned or gently sucked off

Fig. 14. Case x. Pinch grafts on granulating area.

from the dura. By this means the torn meningeal artery is disclosed and ligated either by a stitch or by a silver clip. The muscle, galea and skin are then closed, leaving a small rubber tissue drain for twenty-four hours at the lower end of the wound. By the end of the operation, which should be performed under local anesthesia, the patient in most instances has once more become conscious.

The following case is a fairly typical instance of this class of injury.

Case iii. S. F. Z., a six-year-old boy, surgical no. 26509, was referred by Dr. M. A. Gilbert of Chelsea, Mass. on June 8, 1926.

He had fallen off the end of a truck twenty-four hours before admission, was picked up unconscious and taken to his home. He regained consciousness after fifteen minutes, cried and complained of pain in his head. He continued to have pain in his head throughout the night and until noon the next day, when he lapsed into coma and was brought to the hospital.

Examination showed the boy to be extremely restless and thrashing about the bed. There was an obvious left facial weakness and apparently some lack of use of the left arm and leg, with a positive Babinski reaction on the left. Abdominal reflexes were absent on the left, and the right pupil was larger than the left. The *x*-ray showed a linear crack in the right temporal region.

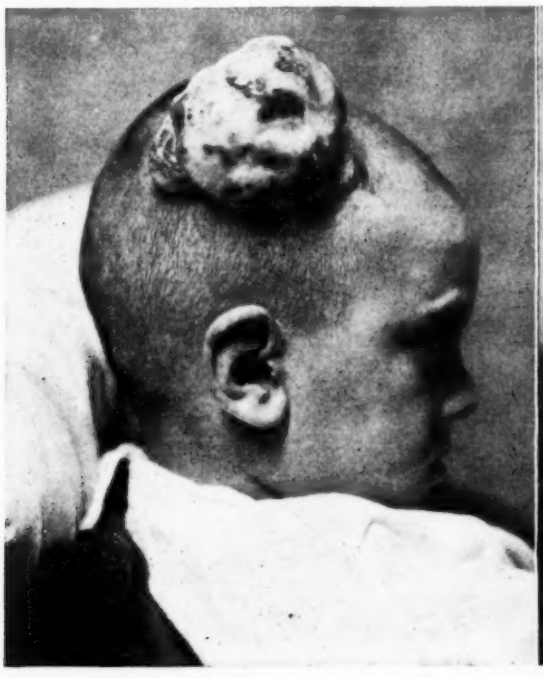

Fig. 15. Case xi. Huge fungus cerebri present at time of admission.

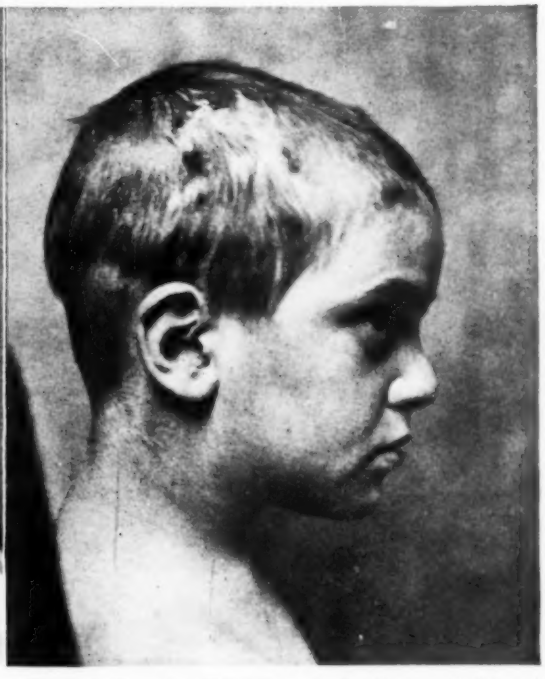

Fig. 16. Case xi. Fungus completely receded at time of patient's first discharge from hospital.

Operation: A right subtemporal decompression was performed one hour after admission. An extradural clot averaging 2 cm. in thickness and 10 cm. in diameter was removed. The middle meningeal artery was found to be torn in two of its branches. These were ligated with silver clips. A small rubber tissue drain was left beneath the dura.

The patient was conscious and rational the next morning. He made an uneventful convalescence and at the time of his discharge (June 25, 1926), was perfectly well. (Fig. 2.)

End-result (one year): He reported on July 30, 1927, at which time he was apparently in the best of health. His decompression area was completely ossified.

There are exceptions to all rules, and since the case just described is almost of the textbook variety it may be well to give the details of one which was not so clear.

Fig. 17. Case xii. Appearance of patient and operative flap at time of discharge.

Case iv. L. R., a girl of sixteen, surgical No. 25047, was referred on October 23, 1925, by Dr. C. Frothingham of Boston.

Fig. 18. Case xiii. Preoperative *x*-ray at time of admission showing huge fragmented area in frontal region extending into frontal sinus.

Fig. 19. Case xiii. *X*-ray showing lateral view of large aerocele within right frontal lobe.

She had been thrown from a horse a few hours before admission, but not rendered unconscious. She got up, walked over to some friends and was taken home. She became somewhat drowsy after getting home and was therefore brought into the hospital, where she continued to be drowsy. She had abrasions over the face and some swelling of the left frontal region. *X*-rays showed a stellate, very slightly depressed fracture of the left frontal bone. (Fig. 3.) This depression would not of itself have been a sufficient indication for operation. The patient was kept under careful observation for forty-eight hours. She became somewhat more drowsy and the edges of the optic discs showed some blurring in spite of magnesium sulphate by rectum. Her left pupil became smaller than the right, and her pulse fell to 66 at times. Taking all facts into consideration, an exploration of her fractured area seemed advisable.

Operation: October 25, 1925. A small osteoplastic flap including the fractured area was turned down. There was apparent immediately an extensive extradural clot 2.5 cm. in thickness, covering the exposed field, and extending down over the tip of the frontal lobe. This was removed by the suction apparatus, and bleeding from small meningeal branches controlled by bits of muscle. The bone flap was then replaced, no attempt being made to do anything to the fractured fragments as there was practically no depression. It may be said that the dura was opened slightly and the cortex found to be normal in appearance. A small rubber tissue drain was left.

She made an uneventful recovery and was quite free of any symptoms at the time of her discharge, November 10, 1925, at which time her pupils were again equal. (Fig. 4.)

End-result (two years): On November 17, 1927, she reported that she was perfectly well.

Class v. *Depressed Fractures.* These, of course, may be of any size and variety, and may involve any area of the cranial vault. They may be seen immediately after the accident or may be brought in for treatment many days or weeks after injury. Neurological signs and symptoms are often present, varying according to the region of cortex that has been damaged.

The treatment is practically always operative unless the depression is extremely slight and there are signs of neither cortical irritation nor compression. The optimum

procedure varies of course with the conditions found. In some cases it may be possible to make a burr opening just outside the depressed bone and by sliding a smooth instrument between bone and dura to elevate the fracture into its normal position. In most cases the whole depressed area will have to be excised, usually best by several burr holes being made around it and by these being connected with cutting forceps. The whole block of bone can then be lifted out, thus ample room being afforded to deal with any hemorrhage. This block should be preserved in sterile gauze until just before closure of the wound, when it can often be flattened out and replaced upon the dura, or if this is not possible the individual pieces may be detached and placed in the same way so that they may form the framework for covering over a large portion of the defect.

A few examples giving some unusual features may be cited:

Case v. I. C., a girl nineteen years of age, surgical No. 28010, was brought into the hospital through the accident room on January 16, 1927.

The meager history stated that she had been in a motor accident less than an hour before admission, and had been thrown forward against the windshield. She had been rendered unconscious momentarily.

Examination showed a star-shaped wound behind the right ear with brain tissue extruding. There was hypesthesia of her whole left side. She was conscious and rational, but highly excited at the time of entrance. *X*-rays showed a depressed fracture in the right temporoparietal region with a large quadrilateral fragment 3 × 3 cm. in diameter and a smaller fragment above this. (Fig. 5.)

Operation: The usual debridement of the superficial tissues was carried out while the depressed bone area was encircled with forceps and removed. There was a large amount of damaged cortical tissue as well as blood clot extruding from a long rent in the dura. The main trunk of the middle meningeal artery had been torn across. This was ligated by a silver clip. The blood clots and pulped brain were removed by suction and the wound closed without drainage.

After operation the patient had a slight

Fig. 20. Case xiii. Anteroposterior *x*-ray after second operation to illustrate replacement of large bone fragments.

temporary weakness of the left arm and leg which had cleared up at the time of her discharge. There remained, however, a definite astereognosis in the left hand. The postoperative scar is shown in Figure 6.

Report: May 9, 1927 (five months after injury). Seemed in perfect health. Has had two convulsions. No astereognosis of left hand, but slight hypesthesia. Normal mentally.

The case just cited illustrates, as did so many cases during the late war, that serious, penetrating wounds of the brain may be cleaned out thoroughly and sutured without drainage provided they are capable of being operated upon within ten to twelve hours after injury. The bone fragments would have been replaced ordinarily, but it was not deemed wise to take this hazard in a case in which brain damage had been considerable and since such a

large dural tear was present. The practically complete clearing up of neurological evidences of brain injury is interesting.

Fig. 21. Case xiii. Lateral *x*-ray after resorption of aerocele for comparison with Figure 19.

The following is an example of an extremely extensive area of depression with unusual operative difficulties:

Case vi. I. R. D., a girl of eleven, surgical no. 38205, was referred on February 11, 1931, by Dr. J. M. Fallon of Worcester, Mass.

She had been in a motor accident on January 5, 1931, which was about a month before admission. She had struck the left side of her head and had bleeding from the nose and from both ears. She was unconscious for three days, being treated at a local hospital during that time. Following her injury there had been slight speech difficulty and certain indefinite mental changes including some loss of memory.

X-rays of the skull showed an immense comminuted and depressed fracture of the posterior, inferior portion of the left temporo-occipital region. (Fig. 7.)

Operation: February 13, 1931. After a skin flap was turned back the upper two-thirds of the depressed area were encircled by bone forceps and removed. When one of these pieces was lifted out a long spicule was seen projecting into the brain. As this was withdrawn, the greatest care being used, some adherent cortical vessels were torn which caused a serious hemorrhage before they could be controlled. This necessitated a small transfusion. The lower portion of the depressed area was elevated without removal. As a final step some of the bone fragments removed from the upper portion of the depressed area were replaced. (Fig. 8.)

Fig. 22. Case xiii. Appearance of patient and operative site at time of discharge.

The child made an uncomplicated recovery and was discharged March 2, 1931. At this time she seemed perfectly normal in every way. She read, wrote and spoke without noticeable defect.

End-result (one year): April 6, 1932. A letter from the child's father stated that she was in excellent health and attending school regularly.

An example of complicating features necessitating a delayed operation is illustrated in the next case:

Case vii. C. D., a child of eight, surgical no. 34741, was referred by Dr. W. A. Bartlett of Manchester, N. H., on August 31, 1929.

This child had sustained a compound fracture of the right parietal region in a motor accident on February 20, 1929. The scalp wound had been sutured at a local hospital,

but broke down and a fungus cerebri developed with a cerebrospinal fluid leak. It was in this stage that I first saw the child in consultation. With the wound in this condition it was obviously inadvisable to attempt an operation upon the fragmented bone. Careful dressings, covering the fungus with gutta percha tissue, were advised in the hope that the fluid leak would stop and the fungus recede. At the end of six to eight weeks this was accomplished, but operation was postponed until some six months after the date of her accident.

X-ray at the time of her admission showed the old depressed fracture in the right parietal region with two loose fragments and a small bone defect. (Fig. 9.)

Operation: September 6, 1929. The old scar was excised and the loose fragments of bone removed, leaving an area of defect approximately 6 × 6 cm. This area was covered partially by replacement of the fragments.

End-result (two years): She made an uneventful convalescence, and in October 1931 her doctor reported that she was perfectly well although there was still a small area of skull defect.

In the next case there is illustrated what is perhaps the simplest method of dealing with a depressed fracture. This maneuver is not always applicable, and of course should not be attempted when fragments of inner table have penetrated through the dura.

Case VIII. S. S., a girl seven years of age, surgical no. 27650, was referred on November 18, 1926, by Dr. C. H. Rapport of Chelsea, Mass.

She had fallen off a piazza three weeks before admission, landing on the left side of her head. She was unconscious for three hours, but seemed perfectly well after that. *X*-rays of the skull showed a linear and depressed fracture of the left frontoparietal region, the linear portion extending into the left orbit. (Fig. 10.)

Operation: November 26, 1926. The posterior depressed portion of the fracture was exposed by the usual skin flap, disclosing an oval area of depression 4 × 6 cm. in extent. There was very marked depression at the posterior end of this area. Consequently, a single burr opening was made above this region and a gutter extended by bone cutting forceps around the posterior end. It was then possible to get a blunt instrument under the depression, and when it was found that there were no spicules on the inner surface it was elevated back into its normal position. A single very slight nick in the dura was evident, but no damage to cortex.

End-result (two years): This child was discharged perfectly well on December 3, 1926. (Fig. 11.) Her mother reported on January 26, 1929, that she was very well in general but that she had some difficulty in concentrating on her studies.

Class VI. *Gunshot Wounds:* Patients with this type of head injury are seldom seen in civil life, but much was learned and written about them in the late war. For those interested in this subject the following articles by Gray,[3] Cushing,[4] de Martel[5] and Horrax[6] may be consulted. Any degree of damage may be encountered, from a simple grazing wound which barely furrows the skull to the severe penetrating wounds with the foreign body retained, or still worse, those which traverse the skull and its contents entirely. The essential features of treatment are to clean carefully the wound of entrance and that of exit if one be present by cutting out the soft tissues, after which the hole in the skull should be encircled with cutting forceps and removed. Bone fragments will be found to have been showered into the brain along the track of the missile, and these should be removed with the greatest gentleness and care by delicate forceps. Clots and pulped brain within the track may be sucked out with a syringe attached to a catheter, or they may be extruded by the patient's straining or coughing slightly. If the bullet is easily accessible it should likewise be removed, but more harm than good is done as a rule by attempting to get the ones which lie deeply in the brain. If left alone they will ordinarily cause no future difficulties.

The following case is the only one of this kind in our series during the past five years:

Case IX. R. P. Z., a boy of twelve, surgical No. 36885, was referred from the accident

room on July 13, 1930. Three hours before admission he had received a bullet wound (.22 cal.) in the right frontal region while playing around a rifle range. He was not rendered unconscious, and was perfectly rational when admitted, although highly nervous and excited. *X*-ray of the skull showed the wound of entrance in the right forehead, together with many retained fragments both of bone and of metal. (Fig. 12.)

Operation: July 13, 1930. The usual debridement of soft tissues and bone was accomplished without difficulty. Most of the indriven bone fragments along the track in the brain were also secured, but a severe hemorrhage from deep within the cortex prevented the finding of one or two of the bone pieces. This hemorrhage was controlled by a small piece of muscle which was placed within the track. No attempt was made to secure the metal fragments as they lay deep within the frontal lobe. The wound was left partly open directly over the hole in the bone.

The boy made an uneventful convalescence. One or two small fragments of bone were extruded through the wound, and the latter closed over completely.

End-result (one year): June, 1931. He has been perfectly well in every way since the accident and doing well in his regular class in school.

Complications

It is not within the scope of this article to deal with all the conditions which may be subsequent to slight or severe head injuries. Suffice it to say that I have picked out from among the cases which have formed the basis of the present study four of the more serious types of sequelae, allowing the brief protocol of each patient to tell its own story as to diagnosis and treatment.

Meningitis is no doubt the most feared as it is ordinarily the most fatal of all the complications of skull fractures. As a rule it develops fairly early, most frequently by way of a perforated drum membrane or fragmented accessory nasal sinus. In the case now to be cited, however, it came late in the course of a severe compound, comminuted fracture in the temporal region.

Case x. T. F. L., a woman twenty-one years of age, surgical No. 21233, was referred April 25, 1924, by Dr. C. K. Benson of Dedham, Mass.

She had been in a motor accident two days previously, at which time she was thrown forward hitting the right side of her head upon the screw which adjusts the windshield. This screw was driven through her skull, and brain tissue was found on the screw. She was taken at first to a local hospital where dressings were applied to her head and after being there two days was transferred to the Brigham Hospital in a semi-stuporous and quite irrational state.

Examination showed a lacerated wound of the right temporal region through which brain tissue the size of a hen's egg was extruding. Dried blood and hair were matted into the wound. There was an evident left hemiparesis and hemihypesthesia with loss of the superficial reflexes on the left side and an increase in the deep reflexes. There was also a right oculomotor palsy. *X*-rays showed a badly comminuted fracture of the right temporal bone with several loose fragments projecting into the intracranial cavity.

Operation was performed the day of admission. Radiating incisions were made from the margin of the wound and the dirty portions of scalp cut away. The protruding fungus was sucked off. All bone fragments were removed (Fig. 13) and the bone edge around the fracture excised with rongeurs for a distance of 1–2 cm. until fresh, unharmed dura was apparent. The whole wound was washed thoroughly with saline, while all necrotic, soft brain tissue was sucked away. The area was then covered with thin gutta percha tissue and left widely open.

A fungus of course developed but although the wound tended to clean up well the lateral ventricle was finally drawn out into the fungus and ruptured at the end of two weeks. A rubber tissue drain was inserted into the ventricle, the wound being dressed daily and always kept covered with smooth gutta percha over which a "doughnut" of cotton was placed to keep pressure off the fungus. The fungus granulated rapidly but a constant leakage of cerebrospinal fluid was present,

and on May 18 the patient's temperature rose to 104.3°F. and three days later she became dull again. It was thought that this was the end, but she rallied and her fever subsided. On June 9 she was very much better and the whole wound had granulated. Pinpoint grafts were applied to the area. (Fig. 14.) On June 28 she was up in a chair, and was discharged on July 11 at which time she was up and about the ward.

End-result (seven years): January 3, 1931. She had been having convulsions at intervals, but her general condition was quite good.

Brain Abscess: This is likely to be late in its development, and manifests itself as a rule first by symptoms of increased intracranial pressure or by evidences of localized brain involvement such as Jacksonian convulsions, progressive weakness of one side, mental disturbances, aphasia, etc. The treatment of a brain abscess varies greatly with many factors, particularly its situation and its depth from the surface. The articles of Eagleton,[7] Coleman,[8] Elsberg,[9] McKenzie,[10] and others may be consulted for details.

The following case illustrates some of the vicissitudes in the treatment of a posttraumatic brain abscess:

Case XI. D. DiM., a boy of seven, surgical No. 26177, was referred on April 17, 1926, by Dr. C. L. Craigin of Portland, Maine.

The child had been in a motor accident on February 7 of the same year, having had an operation upon his skull at a local hospital. Some pieces of bone were said to have been removed from the skull. Since this operation the wound had continued to drain pus; he had recently developed headaches and an increasing weakness of his left arm, together with focal seizures involving the left arm and leg.

Examination showed a left hemiparesis, the left pupil larger than the right, bilateral choked disks, and a fungus cerebri through the old operative scar over the right parietal region. (Fig. 15.) *X*-rays showed an operative bone defect under the area of fungus.

A needle was introduced through the fungus and 40 c.c. of pus evacuated from the underlying abscess. Four days later this process was repeated, and after a third evacuation it was possible to insert and leave in the cavity a small rubber catheter. The fungus increased in size for a time and a cerebrospinal fluid leak developed with the patient running a temperature up to 103°F. Finally the fungus granulated and subsided completely. His hemiparesis cleared up partially and he was discharged home July 26, 1926. (Fig. 16.)

The boy returned to the hospital on January 19, 1927, with a recurrence of headache and some protrusion of the former operative site. His hemiparesis was about the same as at the time of his discharge five months previous, but he had again developed choked disks. Three days after his admission his condition changed suddenly. He complained of intense pain in the back of his neck, became pale with rapid breathing, the protrusion on his head became tense, and within a few minutes he was semiconscious. A needle was introduced immediately through the bulging area and 60 c.c. of pus evacuated from the recurrent abscess. This improved his condition greatly and the process was repeated at two-day intervals for six days, the cavity being irrigated with Dakin's solution, and finally a rubber tissue drain was left in the cavity, and the wound dressed every two or three days. This method of treatment, however, was not found to be sufficient because of inadequate drainage.

Operation: March 31, 1927. The upper pole of the abscess was exposed over an area 2 by 3 cm., its contents evacuated, and the exposed area uncapped. The edges of the wall were then sutured to the subcutaneous tissues with several silk sutures, completely marsupializing the cavity. It was held wide open by gauze packed over rubber tissue.

Convalescence was uneventful after this final procedure, the wound granulating and healing completely so that he was discharged on June 4 walking about but with weakness of the left side most marked in the arm.

End-result (two years): April 8, 1929. A letter from the father said that the boy was in excellent general health and attending school regularly. Weakness of the left arm remained as upon discharge.

Subdural Hematoma: An uncommon late complication of any head injury, perhaps more frequent after the less severe types of trauma, is the slowly forming, encapsulated clot which lies between dura and

brain surface. In the literature this condition has been referred to frequently as "pachymeningitis hemorrhagica interna," a term which seems unfortunate not only because of its length but because it implies an inflammatory process when none is present. Putnam[11] reviewed the subject thoroughly in 1925.

The diagnosis of this condition may be made at times, or at least strongly suggested, by a history of skull trauma followed by an interval of several weeks of freedom from symptoms, and this free interval in turn followed by headaches which become extremely severe. When a subdural clot is either mildly or strongly suspected, it is our custom to make two burr openings in the skull, one on either side of the midline well back in the parieto-occipital region. The presence or absence of such a lesion may be demonstrated by a small incision through the dura. An osteoplastic flap is then turned down over the involved hemisphere and the hematoma together with its surrounding membrane removed.

The following is a typical example in practically all its aspects:

Case xii. M. C. S., a man of twenty-seven, surgical no. 23473, was referred on March 21, 1925, by Dr. J. J. Skirball of Boston.

Five weeks before admission he was struck in the left temple by a wrench. He was not rendered unconscious and continued work the rest of the day. One week after the injury he started to have headaches. These increased in severity until five days before admission when they became violent and were associated with vomiting and the development of diplopia. Examination showed anosmia, nystagmus to right and left, and optic disks with hazy borders. *X*-rays of the skull were negative.

Operations: March 28 and 30, 1925. On the former date bilateral taps were made on either side of the median line of the skull, disclosing a subdural hematoma on the left. On the second date a bone-flap was turned down over the left hemisphere, the dura reflected and the clot with its encircling membrane removed. A small rubber tissue drain was left.

The patient made an uneventful convalescence and was discharged April 18, 1925. (Fig. 17.)

End-result (six years): He has remained perfectly well, returning to work six weeks after his operation, and has worked regularly ever since. He has been seen from time to time up to the present date (November 15, 1931) and has continued perfectly well.

Pneumocephalus: The fourth and last of the complications of skull injuries which I have chosen to discuss are the intracranial pneumatoceles, namely collections of air within the cranial cavity resulting from a fracture. These collections may be extradural in some instances, but the more usual and certainly the more serious are those which lie within the brain itself. During the past year Rand[12] has reviewed this subject fully while reporting several of his personal cases. The commonest injury leading to this complication is a fracture through the frontal sinus with laceration of the dura at the tip of one or both frontal lobes. Following such an injury in which an intracranial pneumatocele has developed one can almost always obtain a history of the patient having coughed, sneezed or blown the nose rather violently. Sometimes during one of these incidents the patient may be aware of a sudden sensation inside the head. After this headaches are likely to develop, and if the air cavity increases to such size as to rupture into one of the ventricles a cerebrospinal rhinorrhea will ensue. This, of course, is a most serious happening, and unless the dural rent is promptly repaired meningitis is almost inevitable. In addition to the features just outlined, the diagnosis of pneumocephalus is made certain by stereoscopic *x*-rays of the skull which show distinctly the location, size and extent of the air cavity, together with its point of origin.

Although conservative treatment, by which is meant rest in bed under careful observation, may in some instances be sufficient to allow the air to absorb, operative closure of the dural laceration seems

without doubt to offer the best chance of forestalling infection. If the torn dura is easily accessible it may be sutured with fine silk, but when the tear lies well down over the tip of the frontal lobe it must be covered by a muscle graft. The latter is simply placed over the laceration and held down firmly for a minute or two until it adheres.

An excellent example of a large intracerebral pneumatocele which was treated by the above method is the following:

CASE XIII. D. S., a young man twenty-one years of age, Surgical No. 29013, was brought in from the accident room at 6.30 A.M. on June 13, 1931. He had been thrown out of a motor car against a tree about an hour before admission. He was rendered unconscious immediately and was still in profound coma upon entrance. There were extensive lacerations and contusions over the right side of his face and head, both eyes being closed with ecchymotic edema. His cold, clammy skin, together with a rectal temperature of 96.2°F. were further evidences of severe shock. A large area of depressed skull fracture was palpable over the right forehead and *x*-rays showed some of the fracture lines entering the frontal sinus while others crossed the floor of the anterior fossa through the cribriform plate involving the sphenoid ridges and the roofs of both orbits. (Fig. 18.)

He was given the usual treatment for shock for three to four hours at the end of which time his condition was improved sufficiently for him to be operated upon.

Operation I: June 13, 1931, 10 A.M. The fractured area was exposed by turning down a skin-flap over the right forehead. Two of the large bony fragments were temporarily removed and preserved in sterile gauze while some of the smaller fragments were permanently removed. The dura was widely lacerated in several places and masses of soft, contused brain tissue together with blood clots were extruding through the tears. These were washed away or sucked out. There was likewise great comminution of the frontal sinus with tearing of its mucous membrane. After a thorough cleaning up, the two largest bone fragments were replaced and the skin flap sutured back without drainage.

After this procedure he regained consciousness and rationality rather promptly and his convalescence was uneventful until July 2d, *on which day he sneezed and blew his nose rather hard.* He said later that at this time he "felt air bubble into my head." *X*-rays were taken the following day and showed a large intracerebral pneumatocele. (Fig. 19.) Because of its size it is quite probable that it may have been present longer than twenty-four hours and that the sneezing of the day before had merely increased its extent.

Operation II: July 3, 1931. The old skin flap was re-elevated and the largest of the loose bone fragments again removed and placed in sterile gauze until the end of the operation. The tears in the dura in the upper portion of the field were healed firmly and new tissue had covered over the widely lacerated frontal sinus. Exploration was therefore carried down over the tip of the right frontal lobe and at its lowest portion, just over the cribriform plate, there was disclosed a round hole in the dura communicating with the pneumatocele. A muscle graft was taken from the patient's temporal muscle and held over the hole until firm adherence was established. No attempt was made to empty the air from the cavity since it was desired to have the frontal lobe and its covering dura come back into its place of close approximation against the skull, thus holding the muscle graft firmly over the hole. The large bone fragment was restored to its original position once more and the skin flap sutured without drainage (Fig. 20.)

The patient again made an uneventful recovery and *x*-rays taken at intervals showed that the air had been entirely absorbed by August 13, 1931. (Fig. 21.)

Report: March 15, 1932. He had up to this date remained perfectly well and had begun to resume his usual activities. (Fig. 22.)

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CERTAIN FACTORS IN THE OPERATIVE MORTALITY OF ACUTE APPENDICITIS*

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EVANSTON, ILL.

THE death rate for appendicitis in the United States in 1930 was 17 plus per 100,000 or a total of 17,687. In 1923 it was 22.3 per 100,000; in 1924, 17.3 per 100,000. The number of deaths attributed to appendicitis in the State of Illinois, in 1929, was 1298 or a death rate of 17.4 per 100,000 population.[1] The mortality from this cause in European countries is apparently much lower. In Paris, France, the death rate was 6.8 per 100,000 in 1929. The mortality in England and Wales for the same period was 7.1 per 100,000 population.[2] During the year 1926 seven European countries showed a death rate for appendicitis varying from 2 to 11 per 100,000 (Table 1).[3] Not only do our statistics on this condition compare unfavorably with those abroad but, according to McClure,[4] the death rate due to appendicitis in this country is actually increasing.

TABLE 1

APPENDICITIS DEATH RATE PER 100,000, INTERNATIONAL STATISTICS

Country	Year	Rate
United States	1927	15
Switzerland	1926	11
Scotland	1926	10
England and Wales	1926	7
England and Wales	1929	7.1
Germany	1926	7
Netherlands	1926	4
France	1925	3
Italy	1925	3
Spain	1926	3
Greece	1926	2

As shown in Table II the average operative mortality in acute appendicitis is about 5 per cent.

In an effort to throw some light on the factors influencing operative mortality the records of 2500 cases in which an appendectomy was performed at the Evanston Hospital in the last ten years were examined. For this study only those cases, 1138 in number, in which the diagnosis of acute appendicitis was confirmed by the pathologist were used.

TABLE II

MORTALITY IN ACUTE APPENDICITIS IN VARIOUS CLINICS

Author	Clinic	Cases	Deaths	Mortality (Per Cent)
Hunter, John B.[5]	London Hosp.	602	21	3.5
Christopher, F., and Jennings, W. K.	Coll. from Evanston Hosp.	1138	47	4.13
Wilensky, A. O.[6]	Collected	1765	86	4.9
Colp, R.[7]	.....	2,841	148	5.2
Eliason, E. L., and Ferguson, L. K.[8]	.....	675	37	5.4
Flint, E. R.[9] ...	Leeds Gen. Inf.	1080	62	5.7
Bower, J. O.[10]..	* Coll. from 27 Philadelphia Hosp.	5121	306	5.97
McClure, R. D.[4]	Ford Hosp.	940	61	6.5

* Mortality in these different hospitals varied from 1.64 to 11.29 per cent.

As indicated in Table III the gross mortality in 955 cases of acute, non-perforative appendicitis was 1.78 per cent. In the 269 of these cases in which drainage was employed the mortality (4.8 per cent) was over eight times that of the 686 cases in which drainage was not employed. The question suggests itself as to whether the drained cases offered a poorer prognosis at the time of operation. However, the diagnosis of acute, non-perforated appendicitis in all of these cases was established by the pathologist. While, no doubt, drainage was instituted in many cases because of the gangrenous appearance of the ap-

* Submitted for publication January 12, 1932.

pendix at operation, we know of many other instances, in this same series, where the appendix was under great tension, obviously gangrenous and associated with free fluid in the peritoneal cavity and in which no drains were used.

Table III

Acute appendicitis (non-perforative), Evanston Hospital, 1920–1931

A. Cases not drained	686	
Deaths	4	
Mortality	0.58	per cent
B. Cases drained	269	
Deaths	13	
Mortality	4.8	per cent
C. Total non-perforated cases	955	
Deaths	17	
Mortality	1.78	per cent

The gross mortality of the 183 cases in which perforation had occurred was 16.39 per cent. All of these cases except three were drained,* and in these three there was no mortality. The absence of mortality in perforated cases in which drainage was not used is suggestive, but the number of cases is too small to draw a definite conclusion.

Table IV

Acute appendicitis (perforated), Evanston Hospital, 1920–1931

A. Cases not drained	3	
Deaths	0	
Mortality	0.0	per cent
B. Cases drained	180	
Deaths	30	
Mortality	16.66	per cent
C. Total perforated cases	183	
Deaths	30	
Mortality	16.39	per cent

Of the 180 drained perforated cases the appendix was removed in 151 cases with a mortality of 17.88 per cent and not removed in 29 cases with a mortality of 10.34 per cent (Table v).

Where removal of the appendix involves handling of the intestine with the probability of dissemination of infection it may be better to omit removal and to be content with drainage.

* "Drained cases" were defined as those in which drains were placed in the peritoneal cavity.

Table V

Acute appendicitis (drained, perforated cases), Evanston Hospital, 1920–1931

A. Cases in which appendix was not removed	29	
Deaths	3	
Mortality	10.34	per cent
B. Cases in which appendix was removed	151	
Deaths	27	
Mortality	17.88	per cent
C. Total	180	
Deaths	30	
Mortality	16.66	per cent

A table was compiled which showed the results of operations for acute appendicitis for each surgeon at the Evanston Hospital who performed five or more operations during the previous ten years. The mortality and operating time were noted.

Table VI

Acute appendicitis, all classes, Evanston Hospital, 1920–1931

Surgeon	Total Cases	Average Op. Time	Total Deaths	Av. Op. Time Fatal Cases	Gross Mortality (Per cent)
A	234	34	14	36	5.98
B	207	39	9	34	4.34
C	115	26½	5	24	4.34
D	57	53	2	37	3.50
E	56	51	0	0	0.00
F	53	26	1	..	1.89
G	50	43	1	..	2.00
Total 7 operators	772	....	32	..	4.14
61 other operators	366	....	15	..	4.09
Grand total	1138	....	47	..	4.13

The two surgeons with the shortest average operating time, viz. twenty-six and twenty-six and one-half minutes, had a mortality of 1.89 per cent and 4.34 per cent respectively, while the two requiring the longest time, fifty-three and fifty-one minutes, had a death rate of 3.50 per cent and 0.00 per cent respectively. It would seem that skill, delicacy in handling the tissues, and judgment cannot be supplanted by mere speed *per se*.

CONCLUSIONS

From a study of the operative mortality of 1138 cases of acute appendicitis at the Evanston Hospital over the last ten years the following inferences may be drawn:

1. In the non-perforated cases of acute appendicitis the operative mortality where drainage was employed was more than eight times that of the cases where drainage was not employed.

2. It is suggested that in perforated cases of acute appendicitis which require drainage, and in which removal of the appendix requires much manipulation of the intestines, the removal of the appendix increases the mortality.

3. The mere speed with which the operation is performed has little influence upon the prognosis.

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* Continued from page 15.

A NEW FRACTURE, X-RAY AND ORTHOPEDIC TABLE

THE AUTHOR'S ORIGINAL ORTHOPEDIC TABLE REDESIGNED*

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AT the meeting of the American Orthopedic Association in Washington, in 1913, I presented my original orthopedic table. Since that time the question has often been asked, "Why can't the construction of the table be changed so that the *x*-ray can be used for making radiographs in cases of fracture and for reducing fractures under the fluoroscope?"

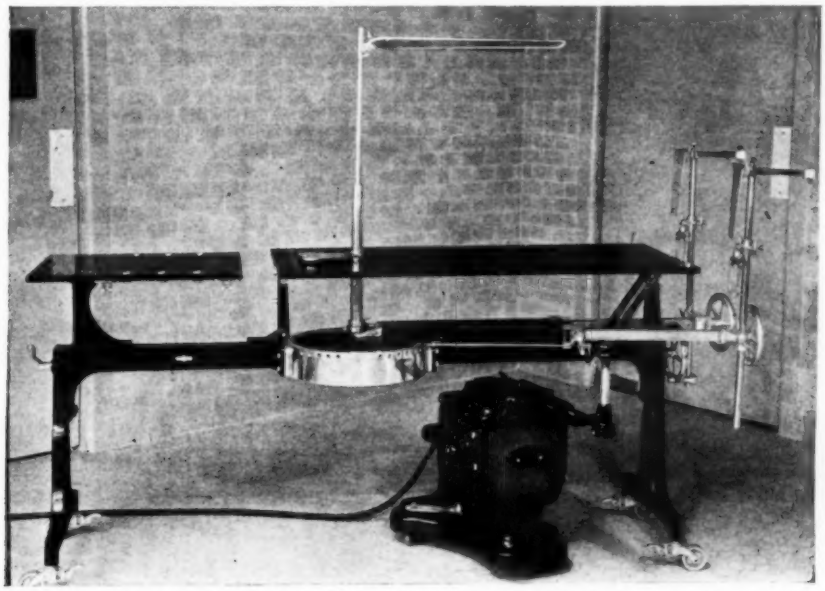

FIG. 1. Author's table remodelled with floor shock-proof *x*-ray unit. All adjustments (gear for lowering top, traction control, and abduction lock) operate from foot of table and convenient to surgeon and assistants. No adjustment at center of table. *X*-ray unit here shown is flexible, handy and can be made to jack up for lateral exposures. This unit suitable for heavy duty. Can be operated continuously for one hour without overheating.

This did not seem practical until improvement had been made in *x*-ray apparatus. There was the double danger of exposure to the *x*-rays and contact with high tension wires. With the use of shock-proof apparatus there is no longer the danger of high voltage wires and refinements made in *x*-ray tubes make it possible to fluoroscope the bones of the extremities[1] with greater safety and effectiveness.

It is my belief that one of the coming developments in fracture treatment will be the use of the *x*-ray[2] in the reduction of fractures. Instead of the *x*-ray being used

[1] Recent trials have shown that one can see quite plainly the bones of the hip joint in an adult when the tube is placed at a distance of 15 to 20 inches. The tube in the new Model D unit has a small focal point suited for short distance exposures. It thus becomes possible to reduce fractures of the neck of the femur and dislocations of the hip, except in individuals with unusual thickness through the hips.

[2] The widespread use of the roentgen ray has been in the field of diagnosis. Roentgen treatment is comparatively limited, limited to affections of the skin and neoplasms, chiefly. In fractures its use for the most part is for diagnosis of fracture and position of fragments. Its application in the treatment of fractures is still in its infancy.

* Submitted for publication August 18, 1932.

chiefly for radiographic diagnoses before and after reduction, it will be used to watch and guide reduction, and check the position of the bone ends during immobilization.[3]

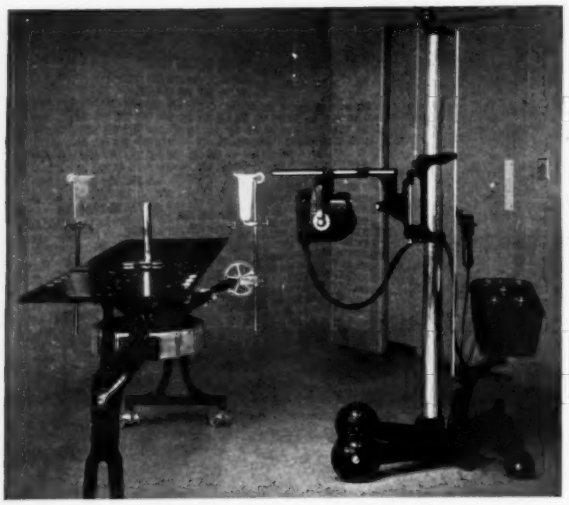

Fig. 2. Table with Model D *x*-ray unit having new small tube and small, compact tube head. This tube will do all that larger tube in Figure 1 can do. But duration of continuous exposure is short. This means interrupted exposures to permit cooling of tube between exposures. Interrupted fluoroscopy is more practical than continuous when limb is securely held in traction. It helps surgeon to regulate and measure exposure time, lessen chance of exceeding time allowance and prolong life of tube. This picture shows tube at side. Procedure has been to take one radiograph from above and one from side for diagnostic record before reduction. Tube is then placed below for purpose of fluoroscoping fracture during reduction. After reduction and immobilization radiographs are again taken in two planes. This tube has a very fine focal point making it suited to short distance exposure and fracture work.

To have to transfer a man with a major fracture to an *x*-ray table to obtain radiographs, then to a fracture table for reduction and immobilization, and then back again to the *x*-ray table is hard on the patient and all concerned. It would help if this could be done on one table and without so much effort. At the same time it would be an added advantage if the *x*-ray could be used to control and regulate manipulation and reduction.

[3] When plaster-of-Paris immobilization is used a radiograph can be taken at any stage without the patient being moved. Thick wet plaster makes fluoroscopy impractical.

To accomplish the above it is necessary to have a safe and efficient *x*-ray apparatus and an orthopedic table which does not materially obstruct the passage of *x*-rays, which permits *x*-ray examinations from below, above and from the side, together with mechanical means for traction, manipulation and suspension of the leg and arm.

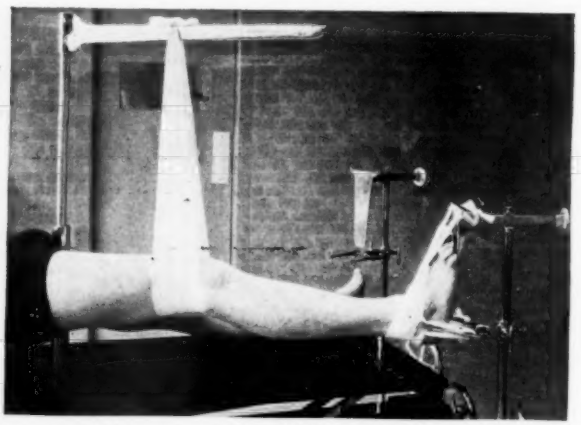

Fig. 3. Subject on table with one leg in traction and suspension and foot fastened to new foot piece. This consists of an adjustable sole piece for control of ankle flexion and a square horseshoe stirrup. Latter drops down when not in use, provides strong traction with little discomfort and regulates rotation of leg.

At the present time I feel we do not know very accurately the effect of traction, manipulation and posture in reducing fractures. These are carried out blindly. We see the results afterward in the radiographs. We do not see the bones during manipulation. We have not seen enough under the eye, studied visually which forces and motions are effectual and which ineffectual and why.

During the past year I have been at work designing a new table in such a way as to preserve the original features of the old table and incorporate improvements in traction, mechanical control of leg and arm, and make it possible and practical to *x*-ray a patient on the table.

This made it necessary to change the construction. As shown in Figure 1, one central horizontal beam with two end supports take the place of the old tubular framework. This provides a clear space below for the *x*-ray tube box. The leg

bars for traction and suspension are off-set to the inside 5 inches and centered on the perineal post.[4] In this way the leg bar is not in the way when the *x*-ray tube is used from below. The abduction ring centered on the perineal post is large enough so that there is no obstruction when *x*-raying the bones of the hip.

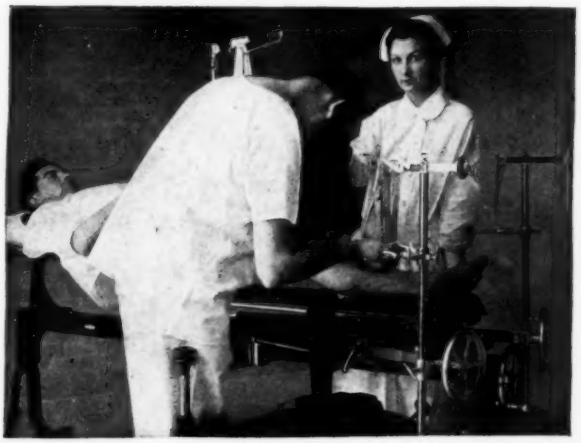

Fig. 4. Subject with leg in traction. Nurse holding box fluoroscope. Surgeon's hands free for manipulation to regulate traction and rotation. Or assistant can carry out manipulations under directions of surgeon. A longer telescoping cone from *x*-ray box to leg will still more confine rays. Lower section of top is split into two removable parts. One half is here shown removed when it is desired to remove all obstruction to rays.

The table top is new. It is composed of a wood fiber surfaced in a thin veneer of bakelite. This offers little obstruction to the *x*-ray and does not produce graining on radiographs. The bakelite veneer gives a clean smooth surface. The lower part of the table top is split into two removable sections (see Figs. 4 and 5).

An added feature is an armboard which makes it better for the handling of fractures of the humerus and of the bones of the forearm. There is better traction and support for reduction and immobilization under *x*-ray control.

[4] Dr. Albee makes a point on his table of having the leg bar pivot under the hip joint. That is a good idea, although it is not easy to determine accurately the joint center in different individuals. And it is not very important, because it is as easy to place the leg in abduction and then apply traction, as apply traction and then abduct. The former is more accurate and easier to do.

The new traction stirrup, as shown in Figure 6, is a distinct asset. I have tried 50 to 100 pounds' traction on my own ankle and it is remarkable what little discomfort it causes. Those who have seen and used it have been surprised how simple it is to apply and how effective the traction. Felt padding can be used under the traction band, but it is not usually necessary.

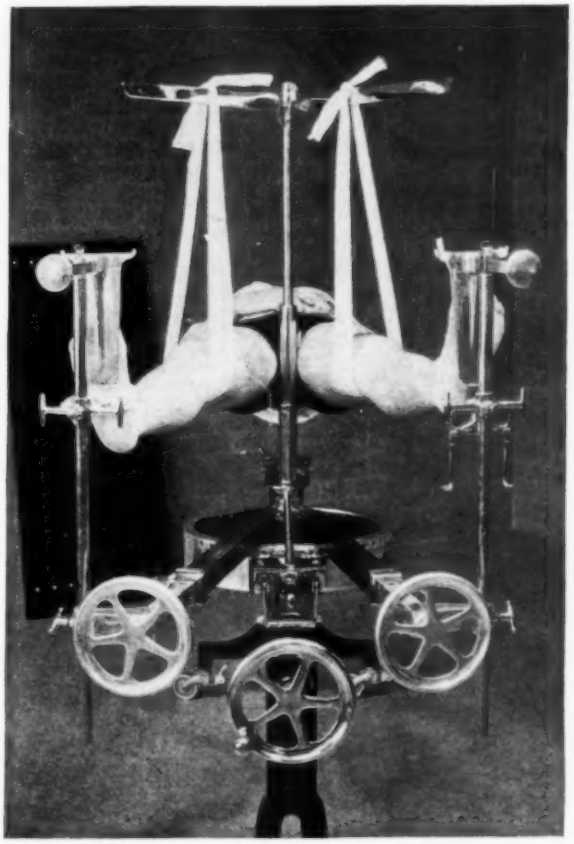

Fig. 5. Subject with both legs suspended and both sections of top removed. These are seen against wall. This photograph shows leg bars offset to inside so that bars do not obstruct *x*-rays when used from below. Left foot is in suspension without traction and traction stirrup is hanging down.

The leg bars are adjustable to a leg 22 inches from perineum to the sole of the foot up to one measuring 43 inches. This makes it suitable for a fairly young child as well as a tall man.

The perineal post is round. All in all, this has been found satisfactory. It is not easy to center the post in front of the

urethra and symphysis. A little more traction on one leg than the other forces the post to the opposite side. This is as it

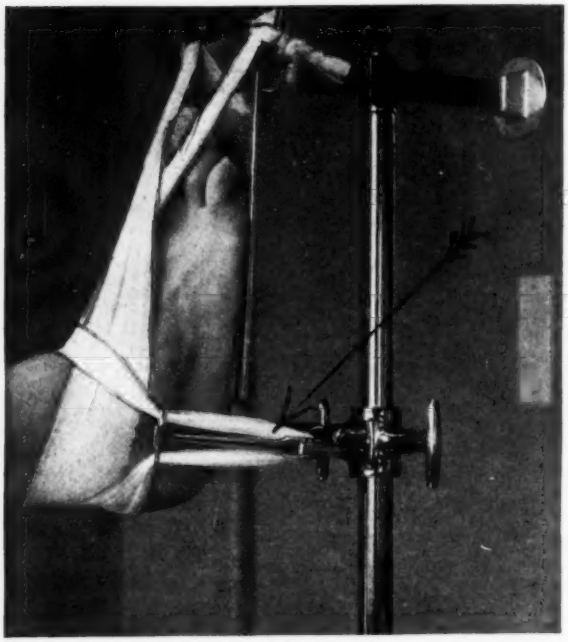

Fig. 6. Method of using traction stirrup. Object has been to find a method which was simple to apply, effective and easy to remove after foot is encased in plaster. Any traction device requires removal in order to be sure there is no undue pressure about ankle. To remove an anklet, Collins hitch or Delbet under wet plaster is not easy. In method shown above a gauze bandage is used. This is looped first over front of ankle, over bar below foot, then back of ankle. This is repeated until enough turns of bandage are made to give body and strength to loop. Turns do not cross anywhere so that when loop is cut at any point all tension is released, and bands can easily be removed. A half ring at upper end of stirrup takes place of a loop or a knot to release traction and remove stirrup after cast has been applied bands are cut as indicated by arrow or any place outside cast. Bands are withdrawn. Half rings are exposed. This requires some cutting of plaster. When freed each arm of stirrup can be hinged outward and then drops down out of way. Foot then slides off sole plate. A bandage loop under ankle as shown may or may not be used to hold foot suspended.

should be. The point of counter-pressure then comes on the ascending pubic ramus. It is natural to apply more traction to the injured leg, throwing the perineal post off center and against the pubic ramus instead of the symphysis.

USE OF TABLE AND X-RAY IN THE TREATMENT OF FRACTURES

My experience in the reduction of frac-

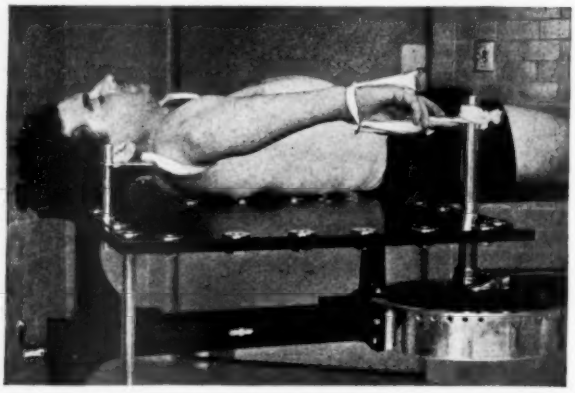

Fig. 7. Subject with armboard attached to side of table. Position for treatment of both bones of forearm, traction, reduction under *x*-ray and immobilization. A metal loop above elbow is used for counter traction with traction to a fixed post. Same form of traction stirrup is used for wrist as for ankle.

tures under the fluoroscope is limited. Generally speaking our knowledge is limited. There is much to be learned and time will demonstrate its possibilities and limitations.

At present the plan of action in a fresh fracture has been somewhat as follows:

A man with a fracture of the tibia, for instance, is placed on the table. Traction is applied to the leg by means of the traction stirrup. Biplane radiographs are taken for permanent record and diagnosis. The fracture is reduced under the fluoroscope in day-light with the *x*-ray tube below. A nurse holds a box fluoroscope. The surgeon has his hands free and keeps his hands away from the fracture area. Reduction is made by regulating traction and by rotating and angulating fragments from the foot. This the surgeon does himself or in cooperation with an assistant.

Skeletal traction by pin, tongs or Kirschner wire can be substituted for the bandage-stirrup traction.

Reduction in difficult cases can be carried out by the subcutaneous introduc-

tion of a lever[5] to guide the fracture ends into position. This has been successfully carried out by Dr. C. M. Kerwin, of West Chester, Pa., especially in fractures of the forearm. He uses a dental elevator the handle of which gives strong leverage action. Recently I have been experimenting with a double handled lever.

After reduction, temporary or permanent immobilization is carried out as the surgeon may choose.

Biplane radiographs are then taken to make the "before and after" record complete.

It will be possible, I believe, to introduce accurately a Smith-Peterson nail in fractures of the neck of the femur through a small incision made on the outer side of the greater trochanter. It is only necessary for some one to devise a guide so that the nail will penetrate directly into the head, not too far to the front or to the back. The depth of the head in relation to the trochanter will give the antero-posterior axis. The fluoroscope gives the other axis (the axis of neck in relation to shaft).

Early trials indicate that a small fluoroscopic screen is large enough because the fracture area is small. A small screen leaves the sides of the limb exposed.

It has been found that this fluoroscopic work can be done in daylight with a box fluoroscope. It is not necessary to wear a hood or accustom the eyes to the darkness

Fig. 8. Traction and manipulation of fracture of both bones of forearm. Reduction under *x*-ray. Nurse holding fluoroscope and assistant regulating traction and rotation.

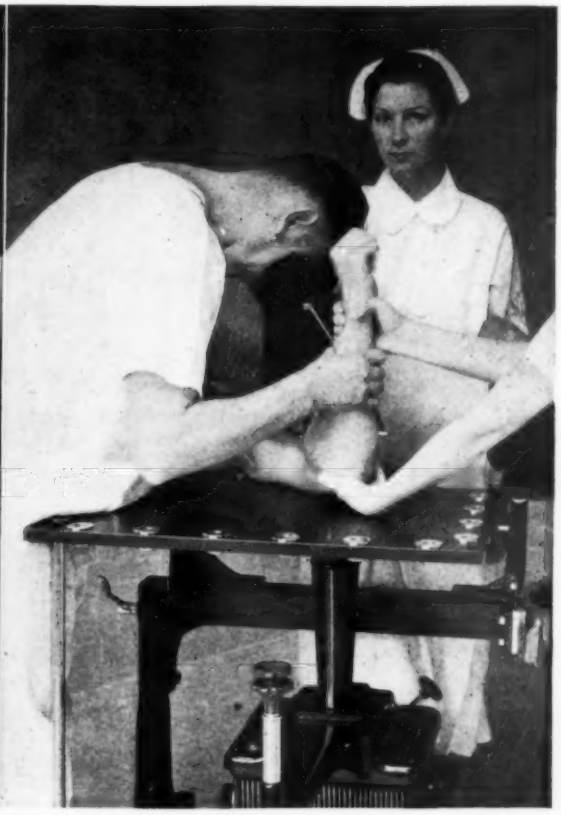

Fig. 9. Position for treatment of fracture of shaft of humerus. Assistant applying traction by grip on elbow or metal loop as in Figure 6 can be used. Counter traction by axillary post similar to perineal post (not visible in picture). Surgeon's hands free to cooperate with assistants in manipulations. This position suitable for immobilization in abduction splints or molded plaster. For immobilization in a plaster spica see Figures 9 and 10.

[5] This calls for as careful surgical technique as an open fracture operation.

except when fluoroscoping the region of the hip. Bone outlines show so sharply that the immediate accommodation of the eye is enough. Gross appearance is all that is necessary. The same fine bone and structural detail required in bone diagnosis is not necessary in reducing fractures.

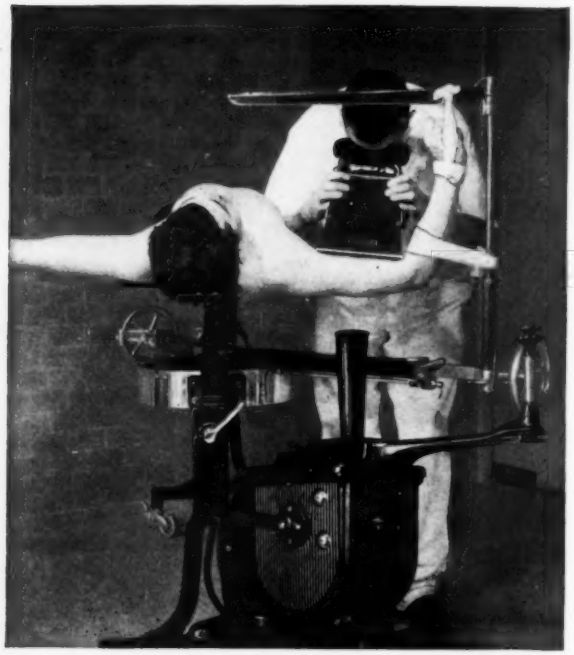

Fig. 10. Position for reduction of fracture of humerus under *x*-ray and application of plaster spica with arm in abduction. Nurse to hold fluoroscope omitted. Narrow board under spine. Counter traction on opposite arm by attendant or by bringing left leg bar into same position as right.

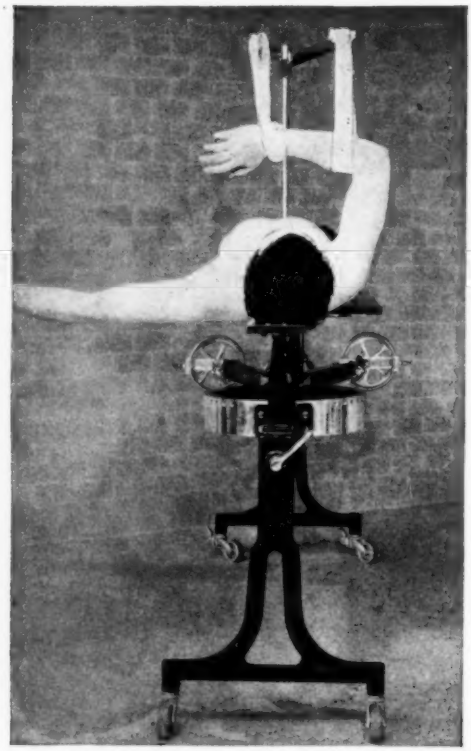

Fig. 11. Position for applying spica with arm in flexion, as described by Albee.

Biplane fluoroscopy for fracture reduction is not necessary or practical. The use of two screens and the need of the surgeon to view from above and then from the side is awkward and interferes with the reduction.

The biplane is necessary for radiographs, for still pictures, for views of fractures at rest. This is not so under the fluoroscope when the bone ends can be moved. When the bones are motionless it is difficult to tell in fractures with overriding which fragment is on top and which below. But when the bone ends are moved to one side or the other, it is not hard to make the distinction. In cases where a lever is introduced to facilitate reduction, or a long needle for local anesthesia, it is easy to see the position of the fragments.

The ability to do everything necessary to reduce fractures in one plane makes it possible to direct the *x*-rays from below with the screen above. This, naturally, is the most convenient for the surgeon and attendants.

The biplane is necessary only for taking radiographic records.

What experience I have had in reducing fractures under the fluoroscope leads me to believe that with practice, the duration of *x*-ray exposure tends to become less. It is different from fluoroscopy in thoracic and abdominal diagnosis where the examiner can take his time, reasonably speaking. In the treatment of fractures the surgeon has a job to do and there is the natural desire to do it with little delay. With practice one can get accustomed to short, repeated illumination of the screen. It is

possible to install an automatic "on and off" switch in addition to the continuous foot switch. The operator then has his

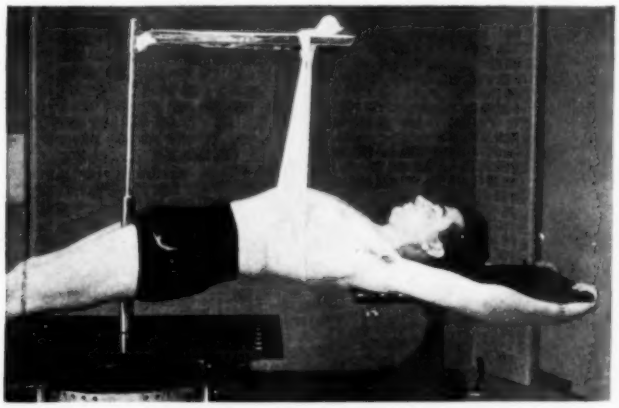

Fig. 12. Position for applying plaster jacket. The shoulder support adjusts to fit a small child or a grown adult.

choice of either. To prevent over-exposure in each case, an alarm with cut-off can be controlled by clock mechanism.

With care and thought it is possible to make reduction of fracture under the *x*-ray reasonably safe because of:

The elimination of exposed high tension wires. The low milliamperage used. The use of a small diaphragm and small screen. The confining of the scattering rays by the use of an adjustable cone from tube box to the patient's leg. The exclusion of the surgeon's hands from the fracture area and from the direct rays. The use of mechanical and instrumental manipulation by the surgeon in place of the surgeon's hands to effect reduction.

I wish to thank Mr. S. Gwyn Scanlan of the Scanlan-Morris Company, and his chief engineer, Mr. W. W. Schaerff, for their interest and cooperation. To Mr. Schaerff belongs the credit for all the details of construction. His product is nothing less than a work of art. Also I extend my thanks to Mr. G. E. Wantz of the engineering department of the General Electric X-ray Corporation for his valuable and enthusiastic help.

To the Sisters of Charity of Glockner Hospital in Colorado Springs, and to Dr. W. P. McCrossin, attending surgeon, I am indebted for the opportunity to use this apparatus on actual cases.

PROBLEMS IN THE TREATMENT OF VARICOSE VEINS*

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THE treatment of varicose veins has attracted such wide interest both among the practicing physicians and the public, that an unbiased discussion of its present status seems timely. It is characteristic of the history of any therapeutic procedure that, following a stage of initial enthusiasm, a second stage of critical reaction follows, during which the entire treatment may be discarded. Only if there is real value in the new methods, only if it means real progress, will they become part of our therapeutic measures.

The history of the treatment of varicose veins shows that vein ligations were already described and practiced by Celsus, that bandaging and vein-trusses were well known to the early pioneers of medicine, and that injections into varicose veins were introduced shortly after the invention of the hypodermic syringe as a natural sequence to the knowledge that an attack of thrombosis may cure varicose veins.

The last ten years, however, have brought a renewed interest in this subject and never before have so many patients been treated by so many physicians. It has become office practice in the hands of the general practitioner. The method of injections has been described, demonstrated at conventions, at county medical societies, discussed in the newspapers. Pharmaceutical houses have inundated physicians with more or less well-written pamphlets and recommendations to use this or that drug with this or that technique. A great deal of confusion arose. The American Medical Association, in order to create a clearing house and help disseminate simple and safe methods, authorized the formation of a Committee on Varicose Veins under my chairmanship, which for two years has organized educational exhibits at the A. M. A. conventions and issued pamphlets to the physicians.[1] The material of these exhibits is assembled at headquarters and may be loaned to state medical societies for exhibition purposes.

The contraindications to the injection treatment of varicose veins, the circulatory tests, the solutions used for injections, the technique, the prevention of tissue necrosis, the management of chronic leg ulcer which is so often on a varicose basis have become fairly well standardized and do not need elucidation. Instead, I have selected certain problems in the treatment of veins, which have received very little discussion in the literature in spite of their importance.

RESTING INFECTION IN VARICOSE VEINS[2]

That varicose veins are frequently infected is generally known. In a group of 31 cases of acute phlebitis in varicose veins, 6 could be traced in all probability to teeth and tonsils, 5 followed acute respiratory infections, 3 were precipitated following operations with prolonged immobilization and in 17 cases no definite source of infection could be found, but they were obviously blood-borne as no local infection was present. The importance of infection in varicose veins is obvious. It constitutes the most important contraindication to the injection treatment. No one would think of treating acutely infected veins with injections. Of far greater significance, however, is the type of vein which harbors bacteria but does not show any evidence of infection at a superficial examination. It has seemed to me, that of all the discomfort and untoward results that may follow

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injection treatment, the activation of slumbering infection is the most important factor and the least emphasized. The analysis of embolic deaths following injection treatment show that invariably two factors are present: an induced phlebitis, and a prolonged immobilization in bed. If one can avoid the former, the latter will not have to be resorted to.

In the course of ambulatory ligations, which we will discuss a little later, sections of the saphenous vein were placed in suitable media and studied by Dr. Arthur Kendall. Of fifty-eight cultures made, over one-half were positive and definitely not due to contaminations. It must be remembered that these veins were ligated in the absence of any clinical infection so that we were really dealing with supposedly non-infected veins. The bacteria grew very slowly and the cultures were frequently negative up to a week or ten days, indicating the sluggish growth of these hibernating organisms.

It seems certain then, that a large percentage of varicose veins harbor bacteria. In our 1500 patients treated in the Varicose Vein Clinic of Northwestern University and in my own private and consulting practice, 25 cases of acute phlebitis have been seen to follow injection treatment. These cases only include massive thrombophlebitides, extending from the site of infection up to the groin, with a marked periphlebitic edema. It is quite a characteristic syndrome. At the time of injection there is no gross evidence of inflammation. From two to seven days following the injection, the patient returns complaining of great pain and often, although not always, a rise in temperature is present. The injected vein and a large segment above it is thrombosed, surrounded by a periphlebitic exudate. The skin is red and hot. Frequently, if the valves are insufficient, the clot extends to the femoral junction.

Prolonged immobilization is not advisable. When the temperature drops to normal, the patients are allowed to get up. The legs are strapped to a point which extends above the upper limit of the clot. We have not lost one such case through embolism. As stated before, embolism following injection treatment is due to a soft, infected thrombus and the favoring influence of prolonged immobilization. If one could avoid the injection of veins that harbor resting bacteria, a most significant danger could be eliminated.

Recognition of Resting Infection. The history of an acute phlebitis should make one suspicious of a possible flare-up. Curiously enough, patients who have gone through an acute attack do not show marked reactions following vein ligation or injections and the same is true of chronic varicose ulcers—the acutely infected ones naturally being treated conservatively. The absence of an acute flare-up in these two groups strongly suggests the development of a local immunity of the veins to the preceding infection. On inspection, such veins do not show any obvious inflammatory reaction such as hyperemia or edema, but sometimes a residual pigmentation is present owing to an old hemorrhagic exudate. After emptying the veins by elevation, the walls are thickened, painful on pressure and small phleboliths are palpable. The most important finding is a rise in skin-temperature above such veins, which can be easily detected with the palmar surface of the hand and exactly determined by measurements with a skin-thermometer. A difference of 3° to 4° as compared with symmetrical regions on the other leg is not uncommon.

There are no systemic changes in these slumbering infections. Temperature and leucocyte count are normal. Much more fruitful seemed the application of certain provocative measures which served to produce a mild activation of the resting infection. I offer three harmless procedures, the first of which can be used without any special equipment.

A simple puncture of the vein is the mildest possible trauma and yet I have

seen it to be followed by a patchy thrombophlebitis in a suspicious vein. The administration of diathermy over the suspicious and another control area for five minutes, gives a marked difference in temperature when observed after twenty-four hours. The most exact data are obtained, however, by applying a ⅙ skin erythema dose of *x*-ray with deep filtration (90–100 R) to the questionable area and to a control area. The rise in temperature is best observed in four hours and is more pronounced over the area with resting infection.[2]

While a negative response to such provocative measures may not exclude "resting infection," a positive result is an important danger signal. It contraindicates injection treatment. The provocative venous punctures or the injection of a few drops of mildly irritating substances such as 50 per cent dextrose solution can be carried out without any special equipment.

Treatment of Resting Infection. When the temperature changes and provocative measures have made the diagnosis of resting infection, first a careful search for obvious foci must be made. The removal of such foci may temporarily aggravate the latent phlebitis. It is more difficult or quite impossible to eliminate pelvic infections, infected thrombi in pelvic veins, which follow childbirth or miscarriages and continuously reinfect the veins of the lower extremities. One such case has been observed for a long time. Every change of weather, every slight exertion, would light up small periphlebitic patches and, at the same time, the thrombosed veins in the broad ligament became painful to the touch.

Repeated doses of *x*-ray for resistant infections, with supportive Unna's casts and mild parenteral protein therapy offer possibilities. In 5 well-observed cases it was possible to clear up the residual infection, so that later injections could be given without any reaction.

The recognition of resting infection, then, is one of the most important safeguards in avoiding untoward reactions.

Patency of Deep Venous Circulation

A second problem which is more often discussed but very little understood, is the patency of deep venous circulation. Every paper, every instruction starts out with the warning not to inject varicose veins in the presence of deep venous obstruction. For years I have been testing for deep venous obstruction with the test of Perthes and, while it may point sometimes to an increased venous pressure in the deep veins, the answer is never convincingly definite.

Let us examine what happens after a deep venous thrombosis. The clot is usually in the external iliac vein, may of course be in the common iliac and hypogastric veins, and may extend down into the femoral. Experimentally, Zimmermann and I[3] have shown that the extent of edema or the possibility of collateral circulation will depend on the extent of the clot to the periphery. That is to say, that there may be "silent clots" in the pelvis without any edema of the lower extremities. That veins will dilate on the lower extremities without the true history of a "milk leg" is not infrequently observed. The venous obstruction in the pelvis calls for collateral circulation. But how long does the venous obstruction persist? The clot, unless it is very long, is reabsorbed and becomes canalized. The vein becomes patent again but there are two definite changes compared with the normal status. First, there is a new collateral network which is now superfluous and, second, there is a deep valvular insufficiency. Thus the important femoral valve which has been described and commented on by Turner Warwick[4] becomes incompetent. We are dealing now, not with a deep venous obstruction, but with a deep venous valvular insufficiency which resembles the congenital weakness or absence of the femoral valve on a hereditary basis. In such patients the hydrostatic

pressure and also sudden changes in abdominal pressure, that occur during straining, coughing, are all transmitted into the saphenous system and cause many communicating valves to become incompetent.

The injection treatment in such cases is not contraindicated, unless there is danger of activating the original phlebitis. There is no danger of shutting off too many venous channels. But the results of the treatment are not always permanent. The increased deep venous pressure may canalize the thrombi or the obliteration does not take place at all.

The recognition of this type of patient is based on (1) strong impulses at the site of saphenofemoral junction or at perforating branches, when the patient is asked to cough; (2) multiple valvular insufficiency of the perforating veins which is recognized by the fact that, in spite of a saphenous compression, the veins fill up suddenly when the patient lowers the leg from an elevated position. Just how we can improve the results of our treatment in this group will be discussed under the next heading.

RECURRENCES

The percentage of recurrences after injection treatment is the third important problem. Quint and I[5] published our findings in 1930 and reported a total of little over 10 per cent recurrences. Nelson Howard and his co-workers[6] at Stanford University have reported the astonishing percentage of 98 per cent recurrences following injection treatment. Outside of these two reports no careful follow-up records have become known, most authors writing enthusiastic articles on immediate results. Now it has been well known from older statistics on operative results, that recurrences increase with every year; that the end of the first year most recurrences are present, but that they increase up to the fifth year.

Vein ligations have been practiced for over a century with the distinct view of cutting off the column of blood from above and Trendelenburg advised saphenous vein ligation to protect the saphenous system from variations of intra-abdominal pressure. Yet a combination of vein ligations with injections on ambulatory patients has not been tried on a larger scale. Quillin and I[7] are reporting on 200 ambulatory vein ligations combined with injections. If the high ligation of the saphenous vein is done with proper indications and proper technique, a recurrence of 0.6 per cent was found. This one recurrence was due to an incompetent femoral valve, a condition that we have overlooked entirely up to the present time and that we believe to be almost uncontrollable.

On the basis of the 200 ambulatory vein ligations, I feel that this procedure has a very definite place in the treatment of varicose veins. The high saphenous ligation protects the injected veins from fluctuations of abdominal and hydrostatic pressure, thus preventing canalization of thrombi. It also reduces the necessary number of injections and places the occluding ligature close to the saphenofemoral junction. By insisting on a short proximal stump and an ambulatory management, we have no embolism to report in the entire series.

Our indications for this procedure are summed up as follows: (1) when there is valvular incompetence of the long saphenous vein above the lower third of the thigh; (2) when there are a few large incompetent communications between deep and superficial system, which can be ligated, and (3) in case of an ascending thrombophlebitis of the saphenous vein.

The operation is contraindicated (1) when the vein is not involved above the knee, and (2) when there is evidence of insufficient deep venous return owing to an old deep phlebitis or deep valvular insufficiency.

The most difficult type of case is the one which shows multiple incompetent communicating veins and an involvement of the long saphenous vein to the groin. Formerly we advocated a high ligation followed by a radical excision for this type,

under spinal anesthesia.[5] On the basis of more recent experience, it may be possible that these patients can be equally well treated by multiple vein ligations followed by injections. The ligatures must be placed on the perforating branches which have to be localized before the operation, and not on the saphenous vein itself, as otherwise an early recurrence will occur.

I have called attention to three problems that must present themselves to every physician who uses the injection treatment: the problems of activating infection, the problem of the deep venous return and the problem of recurrences. The injection treatment itself is fairly well standardized and does not have to be discussed here. But, unless one is on the lookout for complications or insufficient results, this otherwise excellent method will again sink into oblivion. It is with this object in mind, that I brought these problems before you.

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RELIABILITY OF CANCER STATISTICS*

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STATISTICAL evidence is exact when completely collected and correctly interpreted. Figures can be juggled to support any assertion, but that is not statistical evidence. The careless use or the incomplete collection of figures misleads to an extent as to seriously impair any investigation. Most persons who write or read statistical reports are acquainted with the errors of human judgment and the unavoidable errors in computations. Comparisons must be of large numbers to have value, and ratios that are nearly the same should be considered as equal. Minor differences are unimportant. Rates beyond the first decimal are probably of no value. A speaker who gives rates should use round numbers and omit the decimals so that the hearers will be more apt to remember the principal figures. Figures which have no practical value should be omitted. In many instances questions as to correctness of statistics would be avoided if the sources or the methods of obtaining the figures were given.

The figures in reports frequently give only half of the whole truth. They may mislead without intent. Often one reads the number of persons of a certain occupation who have cancer, but such an assertion, without giving rates, has no value. It merely indicates that some people in the neighborhood follow that occupation, and some have cancer. A survey accounts for certain conditions but never mentions the alternatives which are just as important. A spot map shows the location of a certain disease and is useful as far as it goes, but may be remiss in not explaining the conditions in the blank areas where circumstances may make it impossible to have the disease. Comparisons of things which are not comparable are attempted but the reader swallows the assertion and lets it go at that.

Mortality statistics, as usually used, are tabulated from the punch-card records made from death certificates. The punch-card has room for only certain information and obviously it is impossible for every disease or even every part of the body affected by cancer to be recorded separately on the punch-card. Groupings must be formed and the best effort has been made to have the groupings of diseases and of organs made in the most scientific and practical way. These groupings are useful for many purposes but not for every occasion. Numerous attempts are made to utilize them for purposes for which they were not intended, to prove what they will not prove.

Without quoting any authors for fear of being misjudged, a few illustrations will be offered to support these assertions. The figures were obtained by special tabulations from Pennsylvania death certificates for one year and from federal records for that state. The Pennsylvania figures are the tabulations of 9283 cases of malignancy found among 120,000 death certificates. The information secured is not indicated on the regular punch-cards.

Attempts are frequently made to report statistically the duration of the development of cancer and the postoperative length of life. When these figures are the result of careful clinical study they probably are as dependable as it is possible to determine. But when they are collected from death certificates, as has been done, they probably have little if any value. Unless it is obvious, it may be an advantage to state how the records of duration were compiled. The inaccuracies of these figures when obtained from death certifi-

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cates may be illustrated by our investigation. An examination of the death certificates of cancer cases showed that on 22 per cent of many hundred certificates the "duration" of the cause of death exactly corresponded to the two dates showing the length of treatment. To quote the duration of illness as given on death certificates, therefore, is very misleading. There was also a preponderating guess that the duration of the disease was one year, or similar designation.

The postoperative length of life is most reliably obtained by a follow-up of hospital cases rather than only by tabulations from death certificates. Postoperative mortality is not operative mortality, nor hospital mortality. The term operative mortality should be confined to deaths resulting as a complication of an operation. Death certificates do not always record whether or not an operation was done, and when; as an example, among 810 certificates for cancer of the breast only 210 gave a date of operation. What are reported as operative deaths should be restricted to those deaths directly attributable to the operation or to complications indirectly connected with the operation and inevitable deaths which occurred within a given time (as seven days). Examples of such cases would be postoperative pneumonia, cardiac collapse, shock and hemorrhage and intestinal obstruction (with intestinal cancer).

Women are said to have more cancers than men, a meaningless statement. Comparisons are also made of the death rates of the sexes as shown by governmental figures of malignant diseases of the stomach and liver, and of other groups of organs. More than fifty hospitals reported the sex of their patients and showed that 130 men and 68 women were treated for cancer of the stomach; 20 men and 34 women for primary cancer of the liver; 3 men and 11 women for cancer of the gall bladder; and 12 men and 5 women for cancer of the esophagus. Except possibly for cancer of the stomach, lip and skin, sex probably has nothing to do with cancer of organs possessed by both sexes, and a comparison of total cancers is odious.

The increase of cancer has been both asserted and denied. The only just investigation of this subject, I believe, can be made of the only statistical group which contains a single organ, the breast, and should include adjusted rates of only the oft-termed cancer age. The state and federal tabulated records of cancer of the breast can be used for such a study as they contain carcinoma and sarcoma of only the breast, and no other organs are involved.

The number of deaths from cancer of the breast is increasing twice as fast as the population of Pennsylvania. During 1927 the age groups 40 to 59 contained 47 per cent of the deaths from cancer of the breast, and 45 to 64 years contained 51 per cent. The federal statistics show the death rate from cancer of the breast increased in the 40–49 age group from 26.8 in 1910 to 32.7 in 1920, per 100,000 women of that age group; in the 50–55 year group the decennial increase was from 40.4 to 55.5; and in the 60–69 year group the death rate increase in ten years was from 61.0 to 65.0. Specific figures if obtained by similar methods would definitely indicate the actual trend in a death rate, but crude death rates, especially when applied to groups of diseases or of organs, indicate very little of value. We know definitely, therefore, that cancer of the breast shows an increasing death rate in Pennsylvania.

A similar study to determine an increase of deaths from cancer of the stomach or of the uterus or lungs would require (by a study of the original death certificates) a separation of the deaths from cancer of the particular organ from all the others in the group. There may be an increase in deaths from cancer of the female generative organs, but because that group contains many more organs or involved tissues than the uterus, and there are so many possible causative factors, any statement of an increase has no special

value. To determine the increase of gastric cancers it would be necessary to separate the primary cancers of the liver and gall bladder, and also all the cancers from the fauces to the lower end of the esophagus from the group. This can be done only from the original certificates.

The increase in the diagnosed cases of cancer can scarcely be credited to a betterment of facilities or technique for diagnosis. In the 1842 fatal cases of cancer of the stomach the means of diagnosis was recorded for 826; clinical diagnosis in 40 per cent of the 826 cases, laboratory analysis 4 per cent, *x*-ray diagnosis 22 per cent; the rest were diagnosed at operation or discovered by autopsy. In the hepatic cancers dependence was placed upon clinical suspicion in 60 per cent and an *x*-ray diagnosis was made in only 8 per cent.

While the number of deaths from malignancy of the stomach and liver has markedly increased, the deaths from undefined diseases of the stomach have decreased only slightly. To what extent the alleged diagnostic facilities are utilized may be inferred from the reports of 139 hospitals which are equipped with *x*-ray apparatus. At these hospitals, of 130 persons stated to have died of intestinal or peritoneal carcinoma, 70 were in the hospital four or more days, and *x*-ray diagnosis was attempted in only 4 of these patients, the remaining 66 being subjected to abdominal operation without every available diagnostic aid being utilized. All of these suggest, with other similar records, that, in the mass, increased diagnostic facilities are not the effective factor in the increase of recorded cases of cancer.

An increase in cancer deaths shows the need of earlier and better treatment; an increase in cancer shows the need of more knowledge of its causative influences.

Clinics, hospitals or surgeons reporting an increase of a particular disease among their patients make a statement of their experience only, and this has no bearing whatever on the condition of their city or state. Cases are not equally divided among hospitals. Three large hospitals in Philadelphia, as an example, had only 20 per cent of the total gastric cancers of 22 hospitals, but received 79 per cent of the cases of cancer of the esophagus during the year. One of the largest hospitals in the state during six years showed a decrease in lip and tongue cancers, mouth cases showed no change, and the larynx cases doubled; stomach cases quadrupled, rectal cancers increased one-half and cervical one-sixth. These simply show an experience and do not indicate any trend of cancer development.

The increase of deaths from all malignant disease of all organs is undoubtedly a fact, but, according to Ewing, we do not care to know the changes in the totals of all cancers but only those of particular organs. An increase in deaths from all violence means little, but to know there is an increase from one certain form of violence or accident has great significance. The total death rates from all malignant diseases from 1911 to 1930 in Pennsylvania gave the following five year averages: 71.6, 80.3, 89.5 and 98.4. This shows an undoubted increase, but the information is of little practical value. If the group of malignant disease of the stomach and liver is studied for the ten year age group showing the greatest number of deaths, 60 to 69 years, the resulting rates: 189.3 in 1910 and 225.8 in 1920, may create an interest, limited, however, because we do not know to what extent carcinoma of the stomach controlled these rates of a group of organs.

The deaths from cancer of the stomach as tabulated from state or federal death records are the group of deaths classed as from "malignant tumors of the stomach and liver." Many writers accept and quote these figures as representing cancer of the stomach. This group, however, includes deaths from carcinoma, from all the multiple forms of sarcoma and endothelioma. The organs included in the group comprise the fauces, throat, pharynx, esophagus,

stomach, including the pylorus, the liver, gall bladder, bile ducts and gall duct. The person who discusses or writes upon cancer of the stomach must consider these influencing variables if he utilizes the tabulated records of cities, states or governments. To what extent the extraneous cases included in this group will affect the general case, morbidity or death rate from carcinoma of the stomach cannot be herein determined. Suffice it to state, however, that the state records used as an example in this paper showed for the one year the following deaths which have not been heretofore published:

Carcinoma or cancer of the esophagus 132, stomach 1960, pylorus 144, liver 774 (including only 2 having the defining word "primary"), gall bladder 114; and sarcoma of the esophagus 1, stomach 10, liver 20. Not knowing how many of the liver cases were primary, we are not justified in drawing conclusions, although the crude death rate from this collective group is 33.0; from carcinoma or cancer of the stomach and pylorus 22.0; from the liver (many of which cases were doubtless metastatic), 8.1. The group rate, excluding the sarcomas, is 32.7. The group, therefore, does not represent gastric carcinoma. There were 45 deaths from cancer of the mouth and 5 designated as sarcoma. These were not included in the stomach group No. 44, but if half of them were faucial or pharyngeal (as seems likely) they should have been so described and then would have been grouped with the gastric deaths, thus altering the death rate only 0.3.

These examples show the many factors which should be considered when reporting on group rates. It is not likely that the same influence will produce cancer equally in all these organs. While cancer of the stomach and pylorus may increase, the esophageal carcinomas may decrease and adversely affect the combined death rates. Yet, reporters remark that gastric cancer is on the increase and also they make comparison of rates which differ in only minute fractions.

To what extent cancer of the liver influences the statistics of malignancy of the stomach and liver may be suggested by 96 hospitals which reported treating 681 cases of cancer of the stomach and 151 primary cases of cancer of the liver. Cancer of the liver thus comprised over 18 per cent of the group of cases, if these figures are accepted. The deaths of these cases within the hospitals represented 15 per cent of the stomach and 44 per cent of the hepatic cancer cases. Since gastric carcinoma is more amenable to operation or other treatment than is primary cancer of the liver, a very serious error is apparent when death rates of this group of cancers of the stomach and liver are quoted as representing cancer of the stomach.

Hospital records cannot indicate rates in relation to the general population. Only three-fourths of the cancer cases treated in 49 Philadelphia hospitals came from that city, and only 41 per cent of the deaths from cancer in Philadelphia that particular year occurred in the hospitals. These hospitals reported having 554 deaths from cancer, yet the death certificates from these same hospitals showed 682 deaths from cancer that year. Many death certificates of patients dying in hospitals do not indicate that the patients had been in any hospital. The inaccuracies on death certificates are notorious. The records kept by hospitals vary greatly, some are as complete and accurate as it is possible to make them, while others are too inaccurate or incomplete to have much value. Another factor to reckon with is the fact that the International Classification of the Causes of Death does not agree with the lethal causes as agreed upon by hospital authorities and records.

The questionnaire is frequently the only available method for collecting statistics, but because of the great numbers of questionnaires inflicted on busy people the system has become a nuisance. Many persons return wild guesses as their replies and these very seriously damage an important investigation. A brief ques-

tionnaire sent to the hospitals of Pennsylvania included a question of the number of deaths they had from cancer during the year. Their replies gave a total of just 26 per cent fewer deaths than the death certificates from these same hospitals showed for the same period. Thirty-five hospitals claimed fewer deaths and 41 admitted more deaths than could be checked on their death certificates. The hospitals reported receiving 681 cases of cancer of the stomach and 151 primary hepatic cancer cases. Many surgeons may doubt the prevalence of primary cancer of the liver as shown in those figures. Various other discrepancies were revealed by the questionnaire, although several large hospitals went to great trouble to furnish extensive reports. The questionnaire is not an infallible method of gathering statistics. It has limitations and before reporting its result the possible discrepancies should be sought and reported. The questionnaire should be brief, unmistakable in meaning, easy to answer; should omit all questions not absolutely necessary, and should not be employed if it can be avoided.

Let us then be more careful of our statistics; compare comparable factors; give definitions which define; report figures which correctly confirm, deny or explain conditions. Let us determine as far as possible the cause of the differences of figures or rates of similar conditions; be not too critical of another person's records which are correctly shown, but explain the conditions under which our records were obtained and what locality or condition they represent. We should publish statistics which others may understand and employ; use rates adjusted to correctly interpret a definite subject of a definitely involved group of persons; omit comparisons of groups which are irregularly influenced by various factors which cannot be eliminated and which are detrimental to the study in hand; and constantly endeavor to improve our records in completeness and accuracy.

THE WELL-LEG COUNTERTRACTION METHOD

DETAILS OF TECHNIQUE*

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SEATTLE, WASH.

FRACTURES of the lower extremity and the pelvis can now be treated by a new method of skeletal traction which, though simpler in application, obtains better results. The principle depends upon the utilization of the well leg alone for countertraction. As neither ropes nor weights have any part in the reduction process, the well-leg splint by means of its unique leverage attachment makes possible the combination of skeletal traction with well-leg countertraction (Fig. 2). The construction of the splint is so perfected that, once set in operation, disarrangement is impossible, even with wheel chair ambulation. This method reduces essentially the amount of after-care, and provides a safe mode of handling children, the senile and the feeble-minded.

This method of treatment is applicable to all fractures of the femur, including the neck, intertrochanteric, subtrochanteric, the shaft and the distal third; its use extends to unilateral fractures and injuries of the pelvis and all fractures of the tibia requiring traction. The apparatus has a utility in both operative and non-operative work, acting in the capacity of a fracture table, besides serving its main function as a reduction agent. It provides traction and immobilization for conditions of non-union, mal-union, reconstruction and bone-lengthening operations, and also for pre-operative and postoperative fixation for scoliosis.[1]

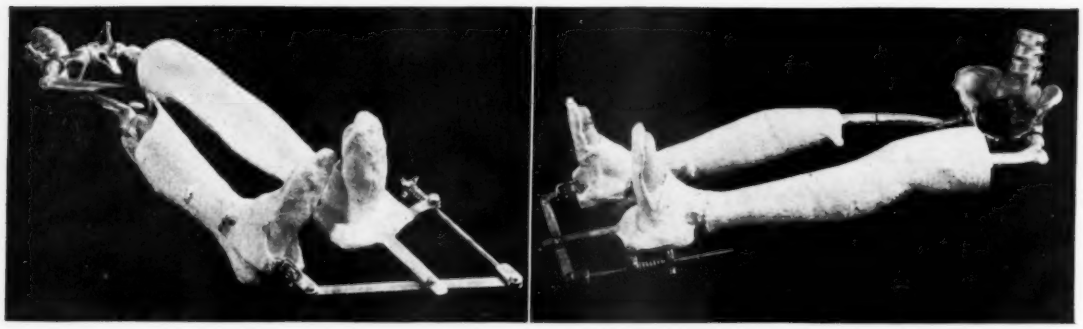

FIG. 1A. FIG. 1B.

FIG. 1. A. Fractured shaft of right femur with shortening and external rotation.

B. Reduction is accomplished and maintained even in sitting posture. Note that hip on injured side has been pulled downward by traction, forcing it into abduction, because countertraction on well side has displaced that hip upwards into adduction.

Immediate reduction, now recognized as essentially a first principle of fracture treatment, is feasible by this method; and since local anesthesia is the general order there is less danger in obtaining early reduction, and consequently the avoidance of prolonged shock, pain and undue swelling. The mechanism of the splint is simple, yet so perfected that reduction may be expeditiously carried out. Very little equipment is required besides splint, sterile set-up and plaster materials, even for the most serious case.

[1] Anderson, Roger. New method of employing skeletal traction. *Northwest Med.*, 30: 444–448, 1931.

New method for treating fractures, utilizing the well leg for countertraction. *Surg. Gynec. Obst.*, 54: 207–219, February, 1932.

* Submitted for publication August 2, 1932.

In theory and in practice the countertraction splint is the very essence of independence. The great freedom of movement allowed the patient could not be effected were the apparatus not an entity in itself, working in conjunction with no other agent than the human body. The basic feature of this method is an unalterable traction force, which operates regardless of movement of patient, and thus since the apparatus is attached to neither bed nor frame, it permits the daily use of the wheelchair. This results in economic as well as physiologic advantages: an institution needs less expensive roentgenologic equipment if the patient can be moved for the taking of films; a shortened period of hospitalization is required when the transfer home may be safely made if subsequent radiographs reveal good position. Movement is the keynote for maintaining metabolism at par and decreasing circulatory and pulmonary complications, benefits directly enhanced by the use of backrest and trapeze. The fact that countertraction is not obtained by lowering the head of the bed, as the well leg alone supplies all countertraction, accrues to these benefits. This freedom from restraint, change of position on bed or transportation by wheelchair to solarium, so increases the patient's general resistance that he feels optimistic, not only concerning the prognosis of his case, but also regarding the skill of the surgeon, a cycle continuously reacting to everyone's welfare.

APPLICATION

A hypodermic of $\frac{1}{8}$–$\frac{1}{4}$ grain morphine sulphate or without scopolamine, grain $\frac{1}{100}$ to grain $\frac{1}{300}$, is usually given on entrance to the hospital. A roentgenographic examination requiring two views or stereoscopic films generally precedes treatment, but the patient need not be taken from the cart on which he entered the hospital for either the films or the application of the splint. To decrease the pain and to lessen trauma the assistant should gently pull on the leg during any necessary manipulation; both legs should be washed and any wounds dressed, preparatory to reduction.

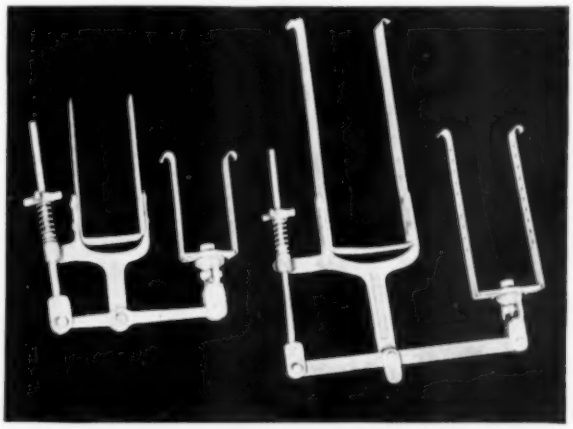

Fig. 2. Splint in infant and adult sizes.

Most of the injuries for which this method is applicable should be treated according to our *standard routine* (Fig. 3). Such a reference in the text refers to the following outline of technique:

STANDARD ROUTINE

1. Apply cast to mid-thigh on well leg.
2. Incorporate splint in cast.
3. Insert pin through tibia.
4. Apply cast to injured leg, incorporating pin.
5. Attach splint; exert traction; adjust rotation; complete reduction.

APPLICATION OF CAST TO WELL LEG

The application of this cast is of the utmost importance. Due consideration to ample protection for all bony prominences must be stressed. First, a stockinet, if at hand, is applied. The leg is well padded with sheet-wadding, especially in the region of the heel and sole; rubber bath sponge, split lengthwise in half, makes an excellent padding for the back of the heel. A thin *flexible* piece of soft felt is next applied to the sole of the foot. Then while the leg is held in adduction, the knee in complete extension, the foot at a *right angle and in slight valgus or eversion*, a plaster-of-Paris cast, extending from one inch beyond the

toe-nails to mid-thigh, is applied by using slow-setting plaster bandages, immersed the minimum time in cold salt-free water.

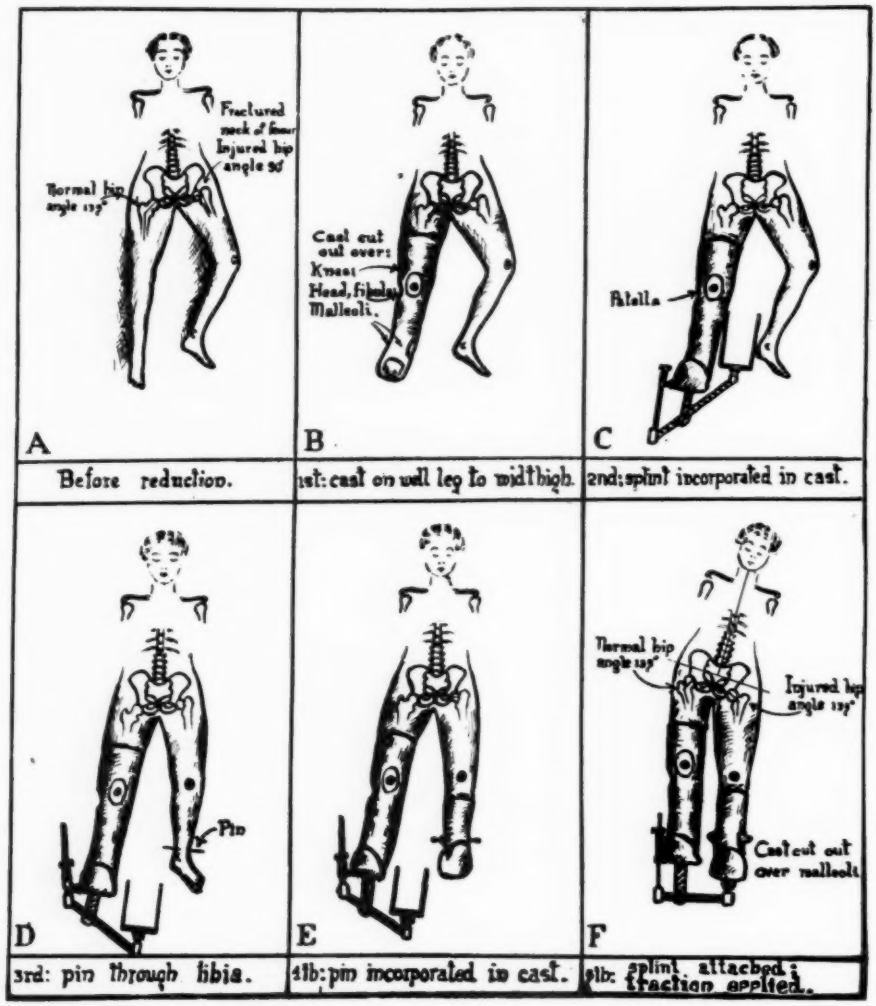

FIG. 3. Steps in application of splint, referred to in text as *standard routine*.

A thick reinforcement of the plaster, 4 inches wide, is smoothly applied to the plantar surface of the cast. Before the plaster sets the cast must be accurately molded up to fit the sole, thus insuring a balanced distribution of the countertraction pressure. The cast is made thicker around the ankle as windows of sufficient diameter are cut to expose the whole malleoli; the plaster is also cut out over the dorsum of the toes and adjacent foot and, if desired, over both sides of the little toe.

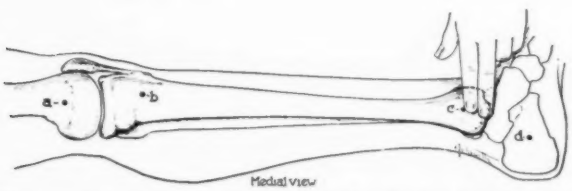

FIG. 4. Selection of sites for skeletal traction. Usual site is indicated by *c*, as employed in standard routine.

By the time these holes are cut the plaster is usually set so that the splint can be attached by an additional plaster bandage. The splint is first unbolted into its three major parts: (1) the countertraction portion, (2) the lever and screw rod and (3) the traction portion. The base of the countertraction portion (Fig. 2) is set at a right angle to the axis of the foot at a level through the center of the malleoli. The

flexible sides of the stirrup are bent by hand to fit the cast, an equal amount of space being left on each side between the stirrup and the malleoli to prevent pressure.

TECHNIQUE OF PIN INSERTION

When the skin over the fractured ends has been washed and shaved, it is scrubbed with ether and painted with iodine. Later removal of the iodine with alcohol or the use of weaker solutions eliminates the possibility of burns. The area around the ends of the fragments is anesthetized by direct injection of 20 to 40 c.c. of 2 per cent novocaine, as used by Böhler. The ankle from 6 inches above the joint to several inches below is similarly prepared, after which 2 per cent novocaine is injected into the skin and down into the periosteum on each side of the tibia. The gloves are then changed and the field draped with towels, in readiness for the insertion of the pin.

A seven-inch solid Steinmann pin of stainless steel, diameter $\frac{5}{32}$ inch, with a four-sided, sharp-pointed end is preferred. The pin is inserted from the medial aspect straight through the center of the tibia, on a level two fingers' breadth superior to the tip of the *internal malleolus* (Fig. 4). This occasions no preliminary incision of the skin, or drilling of the bone for, if the pin is sharp, it can be forced through by rotary hand-pressure alone (Fig. 3 D). A three-inch sterile gauze sponge is spiked over the pin, down against the skin on each side, another piece of gauze about $\frac{1}{2}$ by $1\frac{1}{2}$ inches being twisted around the pin-ends to absorb any moisture running down the pin and contaminating the wounds. The drapes are removed and excess iodine is washed off with alcohol. Sheet-wadding, 3 inches in width, wrapped over the pin and around the leg, suffices to hold the dressing close to the skin, bandage or adhesive being entirely unnecessary. No other prophylactic against infection is required except to leave the wounds entirely alone throughout the period of immobilization.

APPLICATION OF CAST TO INJURED LEG

The cast is applied to the injured leg with the foot held at a right angle. The cast extends from one inch beyond the toenails up to a level 5 inches below the knee joint, firmly incorporating the pin (Fig. 3E). The leg is first well padded with sheet-wadding and a four-inch plaster reinforcement is applied to the sole of the foot and the cast cut out over both malleoli.

Fig. 5. These agents plus splint and plaster material are only requisites for usual fracture case.

The perforations of the traction stirrup are now connected with the pin-ends, those holes selected which permit the splint to set up most compactly against the plantar portion of the cast (Fig. 1). The traction portion is fastened to the cast by plaster bandage, the pin-ends protected by ordinary corks before being covered with plaster. Therefore, unless informed of the transfixion, the patient should be entirely unaware of the pin until its removal.

FIG. 6A.

FIG. 6B.

FIG. 6C.

FIG. 6D.

FIG. 6E.

FIG. 6. Steps of standard routine. Patient, sixty-five years of age, has fractured neck of right femur.

A. Cast to well leg.

B. Countertraction portion of splint incorporated in cast.

C. Pin inserted through lower end of tibia.

D. Incorporation of pin in cast.

E. Traction portion of splint attached to cast of injured leg. Traction and rotation have been applied. Fracture now reduced.

After bolting together the component parts of the apparatus, the next step is to generate traction force by screwing down the traction nut (Fig. 3 F). Correct alignment, by either internal or external rotation, is obtained by operating the rotation nut (Fig. 1). *When the lever arm is drawn down to a right angle with the longitudinal axis of the legs, sufficient traction has usually been exerted.* Meanwhile both the head and feet of the patient are drawn to either the left or right side of the table, corresponding to the same side as that of the injury, while the hips are displaced toward the opposite side of the table. This position, if maintained in bed, permits the spine, paradoxical as it may seem, to set at right angles on the pelvis.

Fig. 7A. Fig. 7B.

Fig. 7. Mrs. L. C. Comminuted fracture of left acetabulum and left ischium with central displacement of head into pelvis, non-reducible by either manipulation or by Buck's extension.

A. Before reduction.

B. After reduction with splint. Patient was removed without pain to *x*-ray room and, as this film shows, there was no disturbance of reduction.

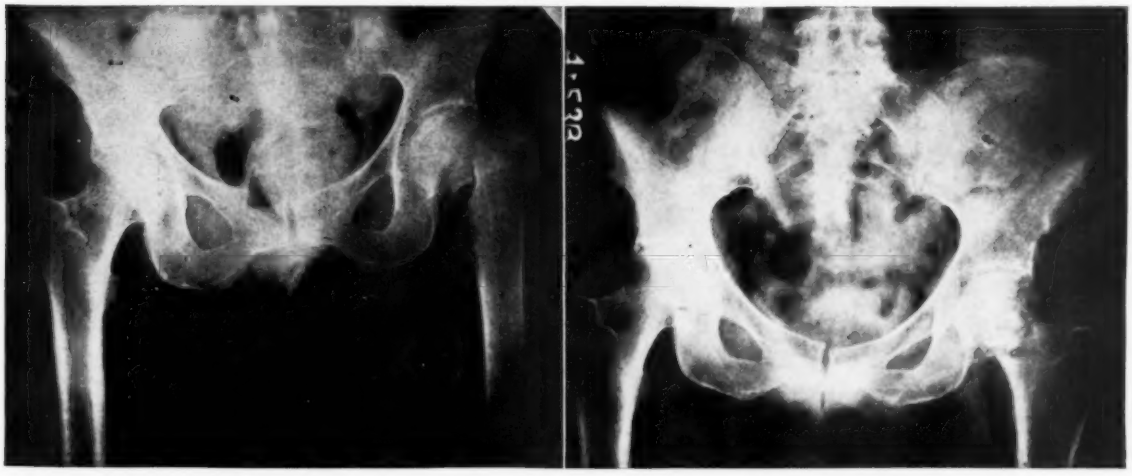

Fig. 8A. Fig. 8B.

Fig. 8. Mrs. I. LaF., aged fifty-eight years. Fractured neck of left femur, which was not detected for seven weeks and, therefore, received no treatment. Patient even tried to walk on it.

A. Before reduction.

B. Film taken day following application of splint.

At this time, or within a short while, reduction should be checked by radio-

graphs, and traction and rotation changed as indicated. A few hours after the patient is returned to his room, the cast should

Fig. 9. Patient, with fracture of left hip, was up within a few days after application of splint.

the trapeze freely; in a day or so he will be able to raise himself up for necessities of toilet. If the patient with a hip fracture is not in a condition of shock, the wheel-chair is often provided as early as the second or third day. The subject with heart trouble can safely be allowed to sleep in a sitting or reclining position; patients with hip and intertrochanteric fractures may be turned on the abdomen daily.

After-care is at the minimum; very little is required except perhaps to cut out over the heel, the little toe or the dorsum of the foot, or to split the upper rim of the cast. All or most of the anterior portions of both casts may be removed as conditions direct. The nurses and the patient also should be instructed to massage the knee joints and to move the knee-caps daily. It is advisable to repeat the roentgenograms as indicated.

Fig. 10A. Fig. 10B.

Fig. 10. Mrs. E. H. Comminuted right intertrochanteric fracture.

A. Before reduction.

B. *X*-rays taken immediately after application, according to *standard routine.*

be cut out over the posterolateral aspect of the head of the fibula and the anterior side of the knee joint.

AFTER-CARE

The patient is not only permitted to sit up but encouraged to do so and to use

If subsequent radiographs in both views or stereos verify good position, the patient may be removed home.

TIME AND MANNER OF REMOVING PIN

No attempt should be made to dress the pin-wounds from the time of the

insertion until the removal of the pin, whether this be a one-month or a four-month interval.

Fig. 11A.

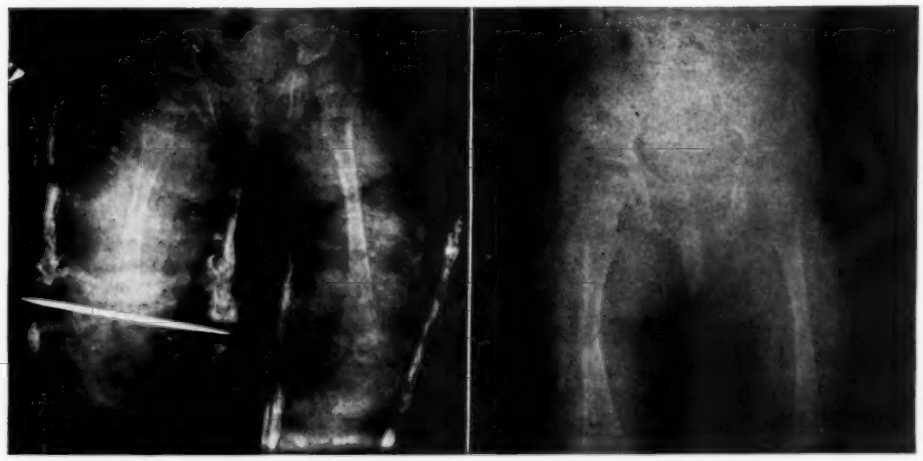

Fig. 11B. Fig. 11C.

Fig. 11. Baby B., fifteen months old. Fractured shaft of right femur; application of splint and perfect reduction obtained by Dr. L. G. Woodford.

A. Before reduction. B. After reduction. C. Final result.

The time of removal of the pin depends upon such factors as the age of the patient, the location and type of fracture and callus formation. In general, the following schedule for the period of traction is adhered to: fractures of the pelvis, four to six weeks; fractures of the neck of the femur, twelve to fourteen weeks; intertrochanteric fractures, seven to nine weeks; subtrochanteric fractures, seven to ten weeks; fractures of the femoral shaft, five to ten weeks; fractures of the distal third, five to ten weeks; fractures of the tibia, four to twelve weeks; and operative cases, six to eighteen weeks.

The patient is unconscious of a securely incorporated pin; hence pain in this region is usually occasioned by looseness of the pin in the cast, a condition calling for

correction. In fact most patients are unaware of even the presence of the pin, when covered by a cast. Because of the power of suggestion, it is poor psychology to discuss this phase of treatment with patient, relatives or student nurses.

Fig. 12. Comfortable position permitted most subjects immediately following reduction, a practical application of theory that this movement in no way interferes with traction.

To remove the pin no anesthetic is required as it is usually accomplished without pain; most children are not aware of its withdrawal, if the act is screened by a pillow. To remove the pin, a hole about 5 inches in diameter is cut around the pin on the medial side of the cast, after which sheet-wadding, dressings, and crusts, if any, are removed. The diagonal ends of a 3 by 6 inch sterile gauze dressing are grasped by the fingers and twisted like a rope; after looping this over the pin, boiled tap water is applied to the center of the gauze where it contacts with the pin. With a rotary movement the plaster which adheres to the pin is removed; the same procedure is then repeated with ether, using three of these sponges. Finally, the technique is repeated with iodine. Just before the pin is withdrawn, a dressing saturated with iodine is wrapped around the pin and held close to the skin, while the pliers pull the pin through from the opposite side. A dry dressing is then applied to the wound and excess iodine removed with alcohol, but if any iodine escapes beyond the pin-wound, the cast should be further cut and the iodine removed. The pin-wounds generally need no further dressing. Unless the whole cast is removed at this time, the opposite pin-wound need not be dressed for several days.

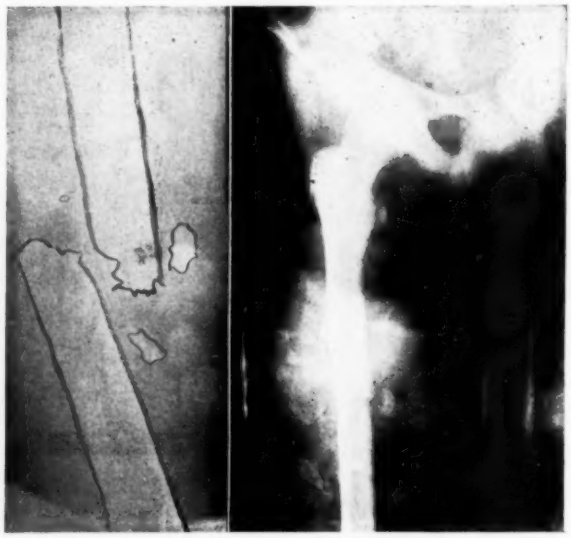

Fig. 13A. Fig. 13B.

Fig. 13. Mrs. R. M. Comminuted fracture of shaft of right femur.

A. *X*-ray taken on receiving patient three weeks after trauma, previously treated by Buck's extension.

B. Anteroposterior view, three weeks after application of splint.

APPLICATION WITH REFERENCE TO SPECIFIC FRACTURES AND INJURIES

Fractures of the Neck of the Femur

Standard routine is employed for fractures of the femoral neck (Fig. 8), with the exception that internal rotation is increased, the amount judged by palpation of the sides of the femoral condyles. As a general rule when the proper amount of internal rotation is present, the foot will appear to be overly rotated internally. Occasionally a small sand-bag or a rolled-up bath towel placed under the trochanter will assist in rotating and elevating the greater trochanter. If desired, these patients are permitted to sit up day and

night, and within a day or so are accorded the use of the wheel-chair.

Since fractures of the neck require little traction, each week the force may be safely decreased up to that point whereby alignment is still maintained, thus insuring pressure contact between the fractured surfaces. Over-traction with its dangers, especially non-union, must be guarded against, the radiograph being the supreme arbiter in regard to retaining end-to-end contact and preserving the normal cervical angle. Stereoroentgenograms have been regarded as the desired test but Clayton Johnson's lateral technique gives additional check. If these principles are closely adhered to, better end-results with fewer cases of non-union will be attained, for this system controls these factors as does no other method.

Intertrochanteric Fractures

Treatment here is also according to standard routine (Fig. 10), except that it is usually best to fix the thigh in external rotation, the degree determined by study of stereoscopic or lateral roentgenograms. In the comminuted variety, especially where the lesser trochanter has been fractured off and pulled upward by the iliopsoas muscle, approximation of the fragments may necessitate a sitting position day and night in bed or wheel-chair. Some of these cases require elevation of the legs on a pile of pillows or box. This flexion assists in reduction; but perfect reduction of the lesser trochanter is unnecessary as the main objective is union of the femoral shaft, and good function can be obtained without normal reposition of all fragments.

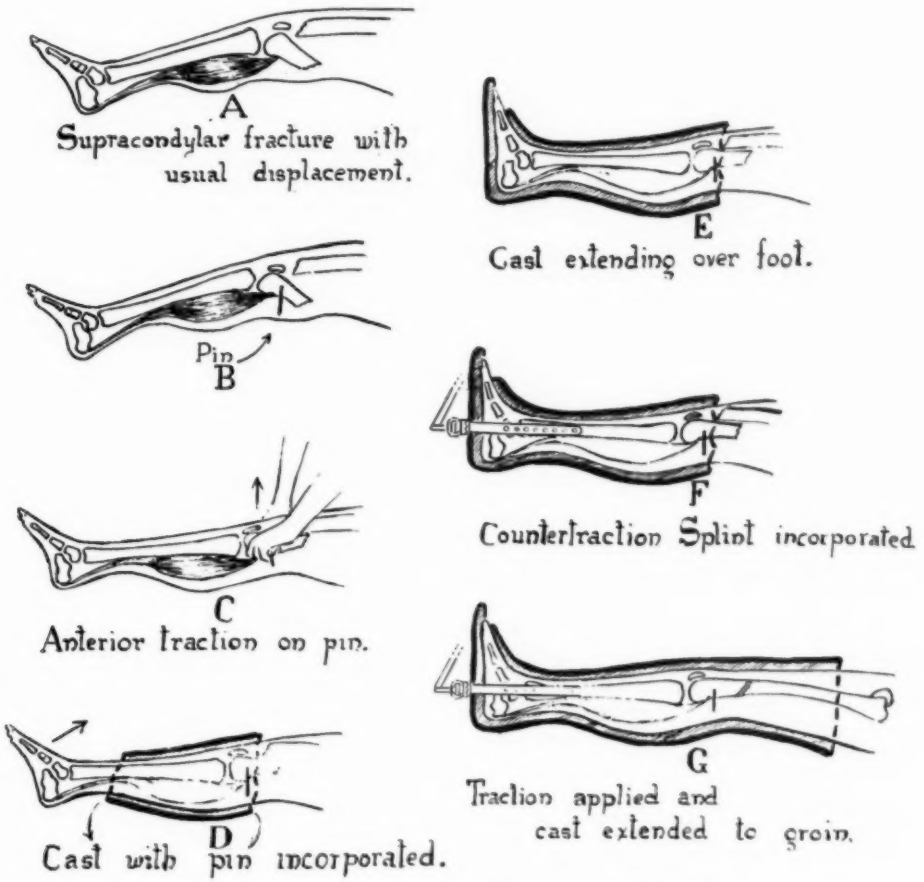

Fig. 14. Original method of treating supracondylar fractures.

Free use of trapeze and wheel-chair, even on the day of reduction, and shortened hospitalization are not incompatible with excellent results.

Subtrochanteric Fractures

In these fractures standard routine is deviated from, as the pin is forced through the center of the femur at a level ¼ inch above or superior to the medical condyle. Transfixion should be approximately straight through, but if the pin does not emerge at about the same level on the opposite side, it is occasionally best to withdraw and reinsert it, checking by film if necessary.

The pin is incorporated in the cast, which is extended just above the pin or to the groin, as conditions indicate. The cast on the well leg is usually extended up to the groin, since these stubborn fractures may necessitate fastening special pressure pads to this cast.[2] In many cases better apposition is accomplished by elevation of the legs on pillows or by a sitting posture.

Since the perforated sides of the traction stirrup slip over the pin when the insertion is through the lower tibia, one may seem to be confronted with an apparently too short stirrup when adapting the method to femoral transfixion. This problem has been solved by curving out the ends of the stirrup so that it is bound and fastened so securely in the plaster that it cannot be pulled out. Hence traction pull is transmitted up to the pin by the solid intervening cast.

Fractures of the Shaft of the Femur

Technique follows standard routine with the following provisos: an 8-inch pin is inserted through the femur, while the cast on the well leg is occasionally extended to the groin (Fig. 13). The splint connection between stirrup and pin is made in the manner described under subtrochanteric fractures.

If difficulty is encountered in obtaining apposition, the distal fragment can be directly controlled by cutting out the cast from around the ends of the pin in order to permit direct readjustment of the fragment by manipulation of the pin. After the desired position is attained, the pin is refastened by plaster bandage. A pressure pad, attached after exposing the fracture site through the casts, is also instrumental in effecting readjustment.[2]

Although the trapeze is permitted after the first few days, the use of the wheel-chair is dependent upon callus formation.

Fractures of the Lower Third of the Femur

For this difficult class of fractures, which include the supracondylar and intercondylar, the technique is slightly altered.[3] After-care is practically the same as for shaft fractures. The following steps in reduction are illustrated by Figure 14.

1. First, the pin is inserted through the distal end of the femur (Fig. 14B). Traction made upon the pin in an anterior direction forces the distal fragment of the femur into the same straight line with the tibia, bringing the knee into full extension (Fig. 14C).

2. The cast is applied from a level 4 inches above the ankle to 1 inch above the pin; this incorporates the pin and also holds the distal femoral fragment and the tibia in the same straight line (Fig. 14D).

3. After this segment of the cast is set, the foot is forced up to a right angle while the cast is extended slightly beyond the toenails (Fig. 14E). Holes are then cut over the malleoli.

4. The traction stirrup is incorporated in the distal end of the cast (Fig. 14F); traction is then applied and rotation corrected.

5. The cast is finally extended from the pin to the groin (Fig. 14G).

If the fracture extends T-shaped into the joint, the condylar fragments must first be aligned before the transverse fracture is reduced. Should these fragments be widely separated from each other, the

[2] The subject of a paper to be later published.

[3] Anderson, Roger. New method of treating femoral fractures in the distal third. (In press.)

medial or lateral displacement is first corrected by a specially threaded pin, the technical details being given in the author's monograph as noted above. By inserting a pair of sliding "sleeves" the fragments are forced together and held as in a vise.

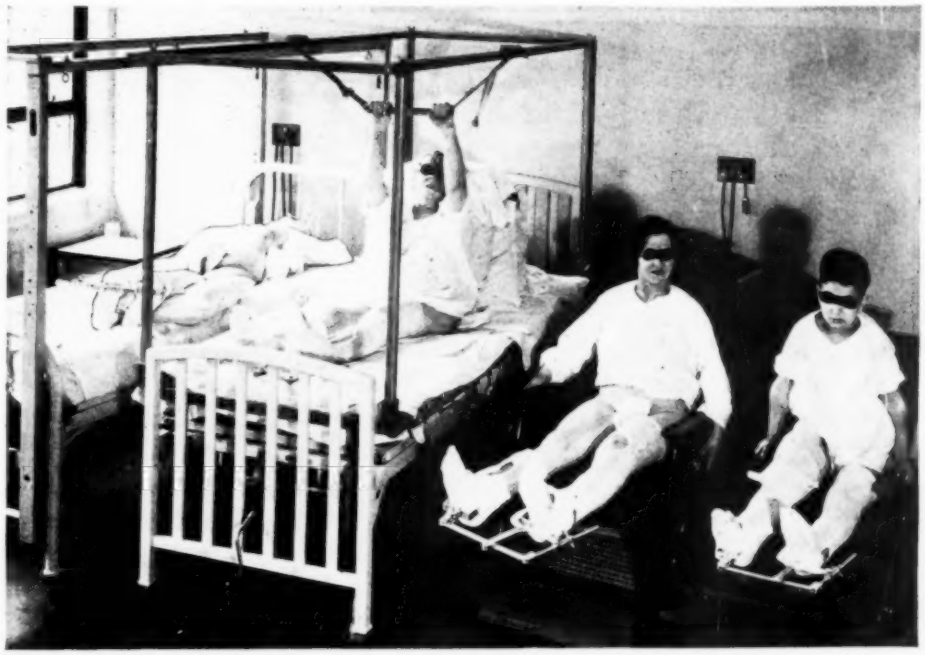

Fig. 15. Reading from left to right: Mrs. N. S., aged eighty-six years, with neck of femur fracture, was turned on stomach daily; Mrs. M. S. sat up day and night because of asthma; Mrs. M. M., with fracture of right hip, made daily use of wheel-chair; Master J. H., comminuted fractures of middle and upper third of right femur. Pin was inserted through distal end of femur.

Fractures of the Pelvis

Standard routine, as previously outlined, is the procedure for pelvic fractures. Although the method is suited for unilateral fractures of the pelvis (Fig. 7), it may be used in bilateral fractures when the fractures are limited to ischium or pubic bones on the opposite side from that of the major pelvic fracture. In fact it can even be used in multiple fractures of the pelvis provided there has been no injury to that small area between the sacroiliac joint and the acetabulum on the well side. In injury or dislocation of one sacroiliac joint or in separation of the symphysis pubis, the splint has also proved successful.

After-care instructions relevant to this class of fractures include the placing of a fracture-board beneath the mattress, and a pad or baby-pillow under the small of the back for support. In most cases these patients are neither permitted to sit up nor are they turned over during the first three to six weeks.

Fractures of the Tibia

Standard routine is employed for all tibial fractures calling for continuous traction, but over-traction should be avoided since very little force is needed for this type of fracture. If a compound wound extends too near the ankle-joint, the pin is inserted through the os calcis.

For that class of tibial fractures which require traction for reduction only, provided a snug-fitting cast be applied for fixation, the splint serves in the capacity of a fracture table and is applied in the following manner. Standard routine is adopted for the well leg; the pin is inserted above the ankle or through the os calcis,

the cast on the injured leg extending just up to the fracture, incorporating the pin. The traction stirrup is then slipped over the pin and incorporated. If the ends extend above the cast they are turned back, thus permitting free adjustment of the upper fragment under traction.

The splint is then assembled and traction force exerted. Since the cast does not encompass the fracture site, the fragments may be manipulated into position and the necessary rotation effected. After satisfactory reduction is accomplished, the cast is extended up 6 inches above the knee. Traction force may be subsequently released; if roentgenographic examination shows that the fracture remains reduced, the well-leg cast and splint may be removed, leaving the traction stirrup only in the cast of the injured member. Thus the apparatus has served as an orthopedic traction table.

A modification of the well-leg method, for quick application without the use of plaster bandages, will be reported on later. For this purpose we have designed an aluminum countertraction shell, lined with rubber, to fit the sole of the adult foot and the posterior side of the leg where it is secured by straps. This device permits either wire or pin for skeletal traction.

Mal-union, Non-union, Bone-lengthening, Hip and Reconstruction Operations

Although standard technique is closely adhered to in these operations, the pin may transfix the femur, with the cast extending 2 inches above the pin. Pin, cast and splint are generally applied a day or so previous to the operation, to afford opportunity for the cast to dry and for the patient to become accustomed to this position. Before commencing to operate, a fair amount of traction force is usually generated, and the circulating nurse should be instructed how to manipulate the splint for further extension and rotation. The fact that the patient can be turned on his side or over on his abdomen for better operative exposure is a decided advantage, especially so since it in no wise interferes with traction. By removing a single bolt one may have free use of the leg for wide manipulation; the bolt can be quickly reinserted when traction and immobilization are again desired.

After the bone-graft is fastened in place and the skin sutured, in most cases the patient can be safely removed to bed. However, it may be necessary to extend the cast up to the groin over an operated femur. Under such conditions as in old, unilateral congenital hips, where a new acetabulum has been reconstructed, it may be advisable to extend the cast to the lower costal margin on the injured side in order to prevent the patient from sitting up. However, the necessary traction must be exerted before the body portion of cast is applied. Some cases call for operation through a large opening cut in the cast; the scoliotic spine responds to this type of treatment. It is clearly seen that the splint and cast apportionment conforms to whatever surgical problem presents itself.

Scoliosis, especially that of the lumbar spine, whether idiopathic or secondary to poliomyelitis, can be slowly adjusted or corrected by means of this splint. But the cast on the well leg is extended up over the body in the form of a spica cast, before any traction is applied. This corrective agent can be employed for some time before operation, which may be performed through a large opening in the cast. On the other hand, fusion operation may be performed first. The splint is later applied according to standard routine with the extension of the cast upwards to the mid-dorsal region, after which traction, the corrective force, is exerted.

ADAPTATION AND SIZE OF SPLINT

The splint has been so constructed that it works equally well with other forms of skeletal traction than the pin. Moreover, the pin, wire or tongs need or need not be incorporated in the cast; for the latter the splint is equipped with an adjustable

foot-plate. Should there be a contraindication to skeletal traction, Buck's adhesive can be used equally well with this countertraction.

This method which has been successfully employed for subjects ranging from a fifteen-month old infant to a three-hundred-pound man demonstrates its wide adaptability, the apparatus being made in adult, youth and infant sizes.

SUBSEQUENT CARE

Continued complaint is a definite indication of something wrong. This can generally be attributed to faulty application of the cast. Permanent indentations in the cast with their inevitable pressure sores will result if the assistant supports the weight of the leg with the fingers instead of the palm. But before the plaster sets the hand must be frequently moved in its position against the leg. Pain in the region of the knees can be avoided by holding the legs fully extended during the application of the casts. Pressure is corrected by splitting or cutting away the offending portion of the cast. In fractures of the tibia and some femoral shaft fractures it is advisable to split the cast completely.

Complaint of pain in the well hip is usually attributable to over-traction, so easily obtained with this method. In spiral fractures, especially, the error of over-traction occurs because one is so liable to misinterpret overriding for what is complete reduction. We must remember that, except for fractures of the femoral shaft, surprisingly little traction is necessary for reduction and immobilization. However, the exigencies of the case may necessitate such an unusual amount of traction as to be the source of pain in the region of the well hip or trochanter. This generally disappears in a short while, though its severity may demand a temporary release of traction, which later can be steadily increased as the force is tolerated. On the other hand, if the films do not reveal over-traction, sedatives or hypodermics may be indicated for some cases. Maximum traction is only required, as a rule, during the first week and can be reduced during the ensuing period. In this sequence of technique the radiograph will be the judge. In the final analysis the best results are attained with a contented patient, and immunity from pain is naturally inferred.

The usual precaution against the danger of too early weight-bearing must be observed. This warning is especially relevant to fractures of the femur; with many shaft fractures it is advisable to keep the patient on crutches or a walking-caliper for a period of six months from the date of accident, while those of the neck frequently require weight protection for a year. After the cast and splint are removed the leg should be closely watched as muscle tension on soft callus results in bowing. In this event it is advisable to apply some form of temporary traction or to resort to corrective cast or brace equipped with pressure pads as necessary.

PARTICULARS FOR CARE OF APPARATUS

Use does not impair the value of the splint. It will not rust and it can be polished with ordinary nickel polish, or a machinist can quickly buff it up.

It is not advisable to boil the splint because aluminum darkens under such procedure.

When the cast and splint are removed, only water should be used to soften the plaster as other solvents act on aluminum.

The same pin may be repeatedly used if the end and edges are resharpened, but the point should be retempered if sharpened on the emery wheel.

By the removal of just two bolts the splint can be divided into three parts—countertraction, lever and rod, and traction—thus facilitating attachment of splint to casts.

The exposed parts of the splint may be wrapped with sheet-wadding to keep the threads, connections and lever arms free from plaster while being incorporated in the cast.

IMPORTANT TECHNICAL CONSIDERATIONS

1. Hold the well leg in adduction at the hip while applying the cast.

2. Hold the well foot at right angles with the foot in slight valgus (eversion or pronation of the foot).

3. Pad the sole of the well foot with *thin, soft, flexible felt* and with a goodly amount of sheet-wadding. A four-inch reinforcement of plaster should be smoothly applied over the entire plantar surface of the cast on the well foot; this should be moulded accurately to fit the sole.

4. Cut sufficiently large openings in the cast over the malleoli of both injured and uninjured ankles before incorporating the splint.

5. The cast should be cut out later over the posterolateral aspect of the head or heads of the fibulae.

6. Pain or trouble with the well leg is usually attributable to careless application of the cast. Continued complaint demands a change of cast. Pain in the region of the well hip is usually indicative of too rapid or too much traction. In most cases when the lever arm is drawn down at a right angle with the longitudinal axis of the leg, the requisite amount of traction has usually been exerted.

7. *Avoid over-traction*, especially in fractures of the femoral neck, by checking with repeated roentgenograms. *Over-traction is a frequent cause of non-union.*

8. Remember the warning of the Cooperative Committee on Fractures: "It is the doctor behind the splint and not the splint that counts in the treatment of fractures."

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*Continued from p. 122.

CHOLESTEATOMA ORIGINATING IN THE SKULL BONES

CAUSING SYMPTOMS OF INTRACRANIAL PRESSURE*

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PHILADELPHIA

INTRODUCTION

CHOLESTEATOMATA originating in the bones of the skull are found chiefly in two situations: in the temporal bone, and in the other bones constituting the cranial cavity. Of these two types the cholesteatomata found in the temporal bone do not concern us. In this situation they develop following chronic middle ear disease, with occasional extension into the cranial cavity. They do not represent primary tumors, but are rather secondary to the chronic inflammations of the middle ear. As such their structure differs from the primary cholesteatomata in the total absence of an epithelial envelope, as well as of the characteristic plant-like cells which make up the tumor. These tumors are filled with lymphocytes and leucocytes and squamae in all stages of fatty and granular changes.

On the other hand, in very rare instances, there are found cholesteatomata which take their origin in the bones of the skull, remote from the temporal bones and middle ear. Such tumors have the typical structure of a cholesteatoma. They possess a true epithelial envelope, and contain the typical flat cholesteatomatous cells. They produce a characteristic *x*-ray picture which it is important to recognize, and may or may not cause symptoms of cerebral compression.

It is such a primary cholesteatoma originating in the occipital bone which we wish to report.

CASE REPORT

J. J., Surg. No. 18752. Impairment of vision, headache, nausea and vomiting, and bony defect in right occipital region of twelve years' duration (1918–1930). Emotional unbalance, reduced visual acuity, binasal quadranopsia, secondary optic atrophy. Large bony defect shown in right occipital bone by *x*-ray. Biopsy revealed cholesteatoma. Evacuation of cyst, entirely extradural. Uneventful recovery.

History: On April 24, 1930, J. J., a white woman of fifty-two, was admitted to the Neurosurgical Service of Doctor Charles H. Frazier, complaining of failing vision in the right eye, headaches and nervousness. She dates the onset of her illness back to 1918, at which time she noted a small "soft spot" in the right occipital region. There were no symptoms referable to this particular site at that time, but the patient noticed that the vision of the right eye was becoming impaired, and that there was blurring after reading for any considerable time. The visual impairment persisted. Two years later (1920), she developed so-called "dizzy spells," described as beginning with a feeling of alternate heat and cold over the entire body, a desire to relax all muscles, and nausea followed by the vomiting of bile-stained fluid. She complained also of generalized headache, more severe in the occipital region, and a peculiar feeling in the head, at times resembling "moving wheels," aggravated by a sudden change of position. After the attack, she felt completely exhausted and drowsy. During the intervals she felt fairly well.

The patient was studied at a local hospital at this time, but according to her statement, no diagnosis was made and she was discharged unimproved.

She suffered from frequent attacks, similar to those described, during the succeeding four years (1920–1924), after which there was an apparent abatement. At no time was there any disturbance of gait, or any incoordination of the upper or lower extremities. The vision of the right eye became progressively impaired, with increased blurring.

* From the Neurosurgical Wards and Laboratory of Doctor C. H. Frazier in the Hospital of the University of Pennsylvania, Philadelphia. Submitted for publication December 23, 1931.

In 1925, the patient developed pulmonary tuberculosis with a reported positive sputum. She spent a year at a mountain retreat and made a remarkable recovery, resulting in the gaining of 95 pounds, and in a complete subsidence of symptoms. The menopause appeared this same year, adding to the general nervousness of the patient.

FIG. 1. Postoperative photograph of patient after complete removal of a diploic cholesteatoma in right occipital bone.

It was not until two years ago (1928) that the patient noted that the headaches in the right occipital region were becoming severe, and that there was tenderness at the site of the bony defect. The "soft spot" which she had first noticed twelve years before, had increased slightly in size until it now admitted the end of a finger. Since 1924 she had been comparatively free of dizziness, nausea and vomiting. The vision of the right eye became neither better nor worse, and although it was considerably less acute than that of the left, she was able to read with the aid of glasses. Blurring still occurred after protracted reading. These symptoms persisted to the time of admission.

On admission, the patient complained of impaired vision in the right eye, a return of "dizziness," nausea and vomiting, and three different types of headache: a dull throbbing ache at the site of the bony defect in the right occipital region, a pain over the vertex, burning in character; and a generalized headache that accompanied the "dizzy spells." She was greatly upset over her condition, showing a marked degree of depression at times, crying for long periods and fearing that she was becoming insane.

FIG. 2. Large area of rarefaction in right occipital region. In center of this area of rarefaction there is an area of increased density probably due to sequestrum.

For the first few days after admission to the hospital, she appeared to be very depressed, reticent and refused to talk about her trouble, stating that she was "tired of being questioned by doctors." On the third night, the resident physician was called to her room where he found her lying in bed, threshing about, holding her head in her hands, staring wildly and crying loudly that she was dying, that there was a machine in her head that was driving her insane. She complained bitterly of headache and nausea, vomiting small amounts of gastric contents. It was necessary to administer a hypodermic to quiet her. During the next few days frequent similar attacks occurred

and following each one, she remained in bed throughout the day. She was often childish in her attitude and was said to be facetious.

Fig. 3. Large portion of inner table has been destroyed and there is some expansion of diploic region.

In the past medical history there was revealed an attack of typhoid in 1910, a history of gallstone colic and cholecystotomy in 1916, and influenza in 1918.

A history of cranial trauma, not particularly clear-cut, but nevertheless present, was obtained. In 1912, while standing on the steps of her home, she was hurled violently across the street following an explosion occasioned by the search for a leaking gas pipe with a lighted match. She was certain that she struck her head in the fall, but suffered no change in consciousness as a result.

Examination: Physical examination revealed a head of normal contour. In the right occipital region was a slightly tender "soft spot," about the size of a quarter. From palpation alone, it was quite evident that there was complete bony destruction of the underlying skull at this site. No pulsation was noted. Several small xanthomata appeared on the upper lids of both eyes. Examination of the chest showed impairment of percussion note over the upper left lobe, with diminished breath sounds and slight limitation of expansion. No râles were heard. The lesion was probably the scar resulting from the old tuberculous infection. The heart was essentially negative. Blood pressure, 166/98. The abdomen was obese and showed an incisional scar in the upper right

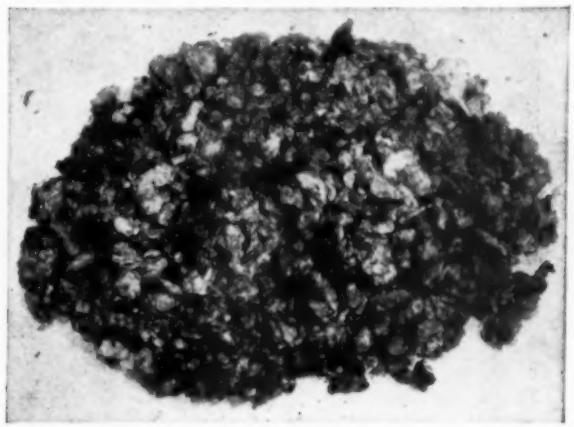

Fig. 4. Large mass of fragments removed at operation, together with capsule of tumor.

quadrant. No organs or masses were palpable. The extremities were entirely negative.

The patient was fully oriented, fairly cooperative, and attentive. The emotional state was variable, at times a marked mental depression and apathy being present, at others an emotional unbalance, with hysterical manifestations. The effects of a long period of introspection, anxiety and concern over her physical condition were well marked. The station and gait were normal. There were no motor or sensory abnormalities noted. The pupils were round and regular, the right measuring 2–5 mm., the left 3 mm. Reaction to direct and consensual light, accommodation and convergence were normal. Ocular movements were complete in all directions. Visual acuity: O.D. 6/60; O.S. 6/20. Ophthalmoscopic examination showed the retinal arteries contracted, the veins tortuous but normal in size, the disc margins irregular and gray in color, the physiological cups filled and the appearance of secondary optic atrophy on both sides. The visual fields showed a lower binasal quadrant cutting with slight concentric contraction. There were no visual hallucinations.

Lumbar puncture showed the cerebrospinal fluid to be under a pressure of 150 mm. of water. The cell and protein content were within normal limits and the Wassermann and colloidal gold tests were negative. The blood Wassermann reaction was negative. The urine

showed a trace of albumin and an occasional hyalin cast.

The *x*-ray of the head showed a large bony defect in the occipital region which occupied most of the occipital bone on the right side. This defect appeared to be similar to that seen after a craniotomy, except that it was not quite as regular. In its midst was a large longitudinal strip which was denser than the surrounding absorbed portion, and was presumed to be a sequestrum. Surrounding this, and occupying practically the entire bony defect was a large area of rarefaction and decreased bone density. The edges of the bony defect were irregular, with spur-like projections extending out into the area of decreased density. The edges were rounded and smoothed off except for the spurs already mentioned. Lateral stereoscopic views showed a large cavity which corresponded to the area of decreased density. The outer table of the skull was thinned in some places. The inner table had been bellied out and formed the inner wall of the rarefied central area. The inner table did not form a continuous line, but was interrupted for rather long stretches, due presumably to its destruction in localized areas. In the lateral views could be seen fine strands of denser tissue which ran across the absorbed area, and gave it a somewhat reticulated appearance. Bone destruction was rampant everywhere.

Because the exact nature of the lesion was uncertain, a biopsy was made on May 6, 1930, by Dr. Frazier. A button of bone was removed from the right occipital region in the neighborhood of the cranial defect, and beneath the bone "there was a circumscribed mass of soft, putty-like tissue which suggested the degeneration of a cyst." Histological examination showed the specimen to be the contents of a cholesteatomatous cyst.

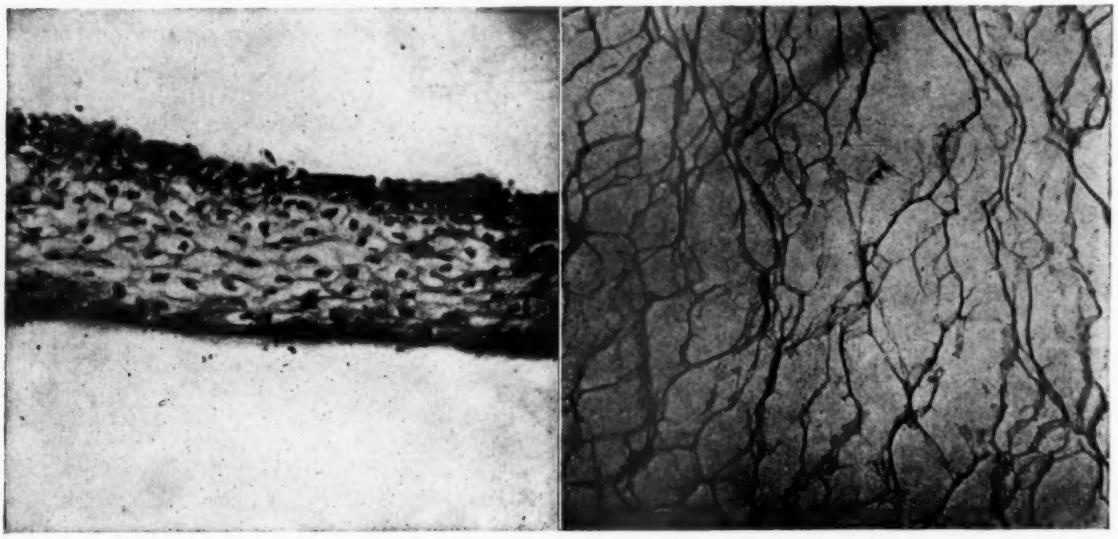

Fig. 5A. Fig. 5B.

Fig. 5. A. High power view showing stratum granulosum with typical flat, polygonal cells characteristic of this layer. Stratum durum not shown. B. In this view are seen characteristic cells of stratum granulosum. There are some features here too of stratum fibrosum which lies immediately above this layer.

Operation: On May 16, 1930, Doctor Frazier evacuated the cyst, about 2 ounces of the above described material being obtained. "There remained lining the cavity what appeared to be the wall of the cyst which could be removed piecemeal by peeling it off. Each section looked somewhat like the skin of an onion." The cavity lay behind the occipital bone and was unilateral for the most part, although it seemed to extend somewhat across the midline. It was more or less the shape of a wedge with its base toward the surface. The cyst was entirely extradural. No attempt was made to repair the cranial defect at this time. A small drainage tube was inserted into the cavity and the wound closed by buried catgut and superficial silk sutures.

For the first few days following operation, the patient complained of similar attacks of dizziness, and there was no appreciable improvement in her mental attitude. However, by the time of her discharge from the hospital,

June 18, 1930, she stated that she felt considerably better, the headaches especially being much less severe. From the time of operation, the wound continued to drain a serous discharge, but the cavity had continued to decrease in size until its volume was measured at 1 c.c.

Shortly after discharge from the hospital, the cavity became infected and a chronic draining sinus resulted. On August 21, 1930, she was again admitted to the hospital and the wound reopened, curetted and thoroughly cleaned. Examination at this time showed the patient's only complaint to be the draining sinus at the operative site. The "dizzy" spells and headache had completely disappeared. She was much brighter and more cheerful. Visual acuity was thought by the patient to be improved, but showed no objective changes.

Pathological Examination: The tumor had the typical mother-of-pearl appearance of these growths. It was extremely friable and fragile, and its layers could be peeled off readily. Among the characteristic large plant-like cells were numerous cholesterin crystals. Although the tumor was removed piecemeal much of the capsule was removed with it, and examination of this revealed an outer homogeneous layer of great thickness, under which lay flattened cells four or five layers in thickness. Since special fixatives were not employed, it is not possible to state whether keratohyalin granules were present in the cells of this layer which Bailey[1] has termed the stratum granulosum. Microscopic studies failed to throw any light on the relation of the tumor to the cranial bones. Nowhere in the tumor could bone be demonstrated, and the tumor capsule itself peeled away readily from the bony surroundings. There was no invasion of the latter.

CLINICAL FEATURES OF THE CASE

There are several points of interest raised by our case: the characteristic *x*-ray findings which should make one suspicious of a diploic cholesteatoma, the relation of the mass to the trauma sustained about six years prior to the onset of symptoms, and the complete subjective improvement following the operation.

The relationship of trauma to the onset of symptoms or to the development of these tumors is, of course, a difficult one. The structure of the cholesteatomata found in the cranial bones is in all respects typical of a primary tumor of this sort. Were the trauma responsible for the development of the tumor we should expect a so-called granulomatous type of cholesteatomatous tumor such as is seen in the temporal bone subsequent to prolonged middle ear infections. There is nothing to suggest this structure in these tumors, and we must therefore not look upon the trauma as the cause of the tumor *per se*, whatever else its rôle may be in the clinical picture. There is further the striking fact that these tumors may develop in the bones of the skull without a history of trauma of any degree. It is nevertheless of more than passing interest to call attention to the history of trauma obtained in the few cases of this sort which have been encountered by others. In Weinlechner's[2] case, a man of forty-five had received a blow on the head when eight years of age, followed by a swelling of the head, and followed four years later by loss of consciousness. Blecher's[3] patient fell on his head and developed a persistent swelling in his parietal region following the trauma. The trauma in Borchardt's[4] patient consisted of a fall on the head from a distance of 4–5 meters followed by subjective symptoms which were referable to the fall. Cushing's[5] patient fell from a horse and struck his head, but suffered no loss of consciousness. Four months later he developed a depression in his temporoparietal region. What the relation of the traumata to the subsequent development of these cases has been is hard to say. No one in our present state of knowledge concerning the origin of cholesteatomata would venture to say that the tumors had developed as a result of the injury. No one has demonstrated that trauma may produce a cholesteatoma. We are justified in saying, however, that following trauma some of these cases of diploic cholesteatomata have

developed persisting swellings at the site of injury, swellings which have later proved to be cholesteatomata.

The postoperative recovery in our case was complete from the subjective standpoint. The mental symptoms, headache and dizziness disappeared entirely following the operation. The visual field defect persisted however, despite the fact that the tumor was entirely extradural and was removed completely, and despite the fact also that there was no evidence of a recurrence. The tumor was removed piecemeal because its nature was not identified until after the bony defect had been entered at operation. It was possible nevertheless to remove the capsule, though it would have been preferable to have removed tumor and diseased bone intact in one large flap. Despite the failure to do so the operative result was extremely satisfactory.

CASES OF CHOLESTEATOMA IN THE CRANIAL BONES

The story of the cholesteatomata has been told many times. Cruveilhier[6] in 1829 first named them pearly tumors because of their striking mother-of-pearl appearance. They were christened cholesteatomata by Johannes Müller[7] in 1838, and renamed pearly tumors by Virchow[8] in 1855. Since then the terminology of these tumors has been a subject of rather heated controversy, some objecting to the noncommittal pearly tumor, and others rejecting cholesteatomata as a name for these tumors because of the presence of cholesterin crystals in many other tumors not related to this group and their absence in some tumors called cholesteatomata. And there the matter stands at the present time. It seems to us that the term cholesteatoma is at least well accepted and established through common usage, and should therefore be used in preference to pearly tumors, even though the objections to the term are well-founded.

There have been very few cases of cholesteatomata arising within the bones of the skull. The condition is rare. In Dr. Frazier's series of brain tumors cholesteatomata represent one-third of one per cent of all intracranial tumors exclusive of pituitary tumors, and among these the variety which is found primarily within the bones of the skull is rare. Probably not more than a dozen cases have been recorded in medical literature.

The location is not constant. The tumors are found in the frontal bone (Esmarch, Weinlechner, Wotruba, Blecher), in the temporal bone (Virchow), in the occipital bone (Borchardt, Alpers and Harrow), in the parietal-temporal area (Cushing), and in the temporo-occipital region (Koerner).

The symptoms which result from these tumors also vary. The tumors are slow growing, remaining extradural throughout their course, and they therefore tend to produce very few evidences of intracranial disturbances. Sometimes their presence is heralded only by a bony swelling or defect. Often the only evidences of their presence are found in the vaguest sorts of symptoms such as headaches, dizziness and vague mental symptoms. Most rarely, as in our case, signs of intracranial disturbance are produced, due possibly to the compression of the brain by the bowed-out inner table of the skull.

In the last analysis the diagnosis of a cholesteatoma within the bones of the skull depends on the *x*-ray findings. The clinical symptoms and signs are usually so vague as to make an accurate localization almost impossible. The presence of a bony swelling or depression which is visible grossly and seen in greater detail in the *x*-ray pictures establishes the diagnosis as well as the localization. The tumor appears to originate between the two tables of the skull. Cushing states that the tables become separated by the tumor, are thinned by pressure and finally absorbed, the inner table as a rule suffering more than the outer. There is a bowing-out of both tables of the skull (Blecher), bone absorption taking place chiefly within the substance of the bone. Occasionally there is erosion

of the inner table of the skull by the tumor. This may occur in one or more places, but it does not seem to reach a size which permits the tumor to break through. The cerebral symptoms which these tumors produce are not the result of extension of the tumor through the bone and into the cranium, so much as to the compression of the brain by the arching of the inner table of the skull.

The *x*-ray picture produced by one of these diploic cholesteatomata resembles, as Cushing has so aptly said, the sort of defect which might have produced by an old craniotomy. Since the early cases reported were not studied from an *x*-ray standpoint, it is only recently that the roentgenologic features of these tumors have become known.

The cholesteatomata arising in the bones of the skull are very slowly growing tumors. Blecher believes that they are usually noticed first at ten or fifteen years of age. They destroy the cranial bones in which they grow, but are only locally malignant. While they erode the inner table of the skull, they do not penetrate through the dura and invade the brain substance. Both by virtue of their slow growth and their strictly local nature there tumors are benign and can be successfully removed surgically. The art in their removal consists in the complete extirpation of the epidural membrane which surrounds them. So long as this is not removed the possibility of a recurrence is imminent. Furthermore the membrane can be removed most completely before the cyst is emptied of its contents. In our case it was felt that the entire membrane had been removed despite the fact that the tumor was removed in fragments and the contents emptied before the removal of the tumor. Thus far no recurrence has been noted.

CONCLUSIONS

1. A rare type of cholesteatoma, primary in the occipital bone, is reported.
2. The tumor was successfully removed at operation.

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TREATMENT OF TRAUMATIC TETANUS

WITH REPORT OF FIVE CASES*

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BEFORE going into the treatment of tetanus, I wish to mention some of the important facts about this condition. There are four diseases which are very similar: shingles, rabies, tetanus and acute poliomyelitis. The toxins of these diseases are alike in their selective influence upon the nerve tissue. The mortality rate of tetanus is variously given. In some of the most recent statistics the rate has been placed at 85 per cent after convulsions have begun, and 95 per cent where convulsions begin within ten days from the time of the injury. The mortality rate will, of course, be lowered when the symptoms come on after ten days and when the wound is on the extremities.

The cause of death in tetanus is exhaustion or cardiac failure due to long-continued or severe clonic convulsions or respiratory failure due to spasm of the glottis or diaphragm. Calvin and Goldburg,[2] Chicago, state that the mortality from tetanus at the Cook County Hospital has not decreased in the past fifteen years in spite of the fact that in the last five years larger amounts of antitoxin were used and it was given intraspinally more often. A larger number of cases occurred between the ages of ten and fifteen years. Tetanus was five times as common in males. Tetanus following gunshot wounds had a high mortality rate of 95 per cent. The incubation period in 56 per cent was under ten days. The mortality at Cook County Hospital of cases under ten days was found to be 84 per cent.

The treatment of tetanus is difficult because it is not known the patient has tetanus until it has reached his spinal cord and manifested itself by muscular spasm. It is for this reason that a planned vigorous treatment must be carried out in all cases early; do not defer more active measures until the symptoms become more severe. Every case of tetanus is serious enough to receive the most vigorous treatment and be prepared to institute it at once. We are not treating a disease which we treat symptomatically.

The treatment resolves itself into (1) neutralization of the toxins present; (2) relaxation of muscular spasm as near as possible; (3) prevention of absorption of toxin.

1. NEUTRALIZATION OF TOXIN

In my opinion the toxin already found should be met with a sufficient amount of antitoxin intraspinally and intramuscularly, but not intravenously. My reason for not giving it intravenously is because of the shock and prostration to an already weak and tired patient due to anaphylaxis. During the war no case of tetanus in France recovered if treated by the intravenous route only. The intraspinal administration is less often followed by anaphylaxis. All patients should be tested for anaphylaxis and if there is any reaction they should be desensitized. This can be accomplished by this simple method. (1) Take 5 c.c. of serum, dilute with 50 c.c. of normal saline, inject 1 c.c. of the mixture intravenously; four or five minutes later inject 3 c.c.; five minutes later 10 c.c. are given and then 25 c.c. of the mixture can be given. After a further delay of fifteen minutes the serum can be given intraspinally or intramuscularly. Another point to be remembered about the administration of serum is that it may be forty-eight hours before all the serum is absorbed when given subcutaneously, whereas when given intramuscularly it is absorbed within twelve hours. While I am discussing antitoxin there is one thing that should be mentioned concerning its use in the prevention of tetanus. The

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French found that the period of immunity produced by antitoxin lessened with each succeeding dose. After the first immunizing dose they found it to be good for twenty-one days; after the second dose, seven or eight days; and after a third dose, even a shorter time. Therefore in an old case of gunshot wound, they gave the patient 15,000 units two days before performing a secondary operation lest the operation activate some dormant bacilli. The amount of antitoxin I have used in this series of cases has been 7500 units concentrated intraspinally, 40,000 subcutaneously, or better still, intramuscularly, this serum all to be given the day I see the patient. I have not used larger doses because I felt these were sufficient. I have not repeated my antitoxin because I think that to give many large doses over a considerable period invites the anaphylaxis reaction. When I began the series, it was at the suggestion of my partner, Dr. C. B. Earle, that I begin the combined use of carbolic acid and serum. I have found since that the French have used the combination of serotherapy and carbolic acid. In what manner the carbolic acid acts, I do not know any more than the physician knew how quinine acted before he knew the cause of malaria. I am convinced that carbolic acid has a curative action on tetanus if the patient is treated early enough to get the effect of the treatment. The method of treatment is to inject a 2 or 3 per cent solution of carbolic acid in the amount of 1 to 5 grams in twenty-four hours, preferably to be given twice a day, the first dose to be injected around the wound, and if it is on the extremity, to inject up along in the region of the nerve trunks. The dosage of carbolic can be increased daily the urine being watched twice daily for a smoky cloud. As soon as the urine becomes dark and smoky in appearance, stop the carbolic acid.

2. Relaxation of Muscle Spasm

Protecting the patient from external stimuli needs consideration; that grand jumble of being admitted to the hospital should be smoothed out a bit. There is no danger of tetanus to the other patients, but the other patients are a great danger to the patient with tetanus. He should have a quiet room and if possible a quiet nurse.

I have not used morphia in this series of cases to control the spasm, because no drug will control the spasm completely and large quantities of morphine certainly will not help the patient. I have used sodium amytal for these cases and find it has worked well toward relieving the patients of that horrible anxiety they all have. The patients have all been conscious the entire time during their illness, I kept them under the influence of sodium amytal for weeks without any bad effects on the kidneys, and with no excitable or delirious effects.

3. Prevention of Absorption of Toxin from Wound

This was accomplished by the application of pure carbolic acid in the wound if it had not healed, and the injection of a 2 per cent carbolic solution around the wound. I do not believe it is wise to be continuously probing or treating the wound because excitement of some dormant bacilli by such practice may occur. The fluid balance of the body must be kept up. This can be done by proctoclysis of soda saline solution, or intravenous glucose 10 per cent, when the patient has much trouble swallowing.

Polloni[3] gives a survey in April of this year of a twelve-year period in Rome. Eliminating the fulminating cases, he had 53 cases treated with carbolic acid alone with a mortality rate of 30 per cent.

Case Reports

Case 1. G. O., Chart No. 2491, City Hospital. Referred by Dr. H., boy, aged fifteen. Admitted to hospital November 26, 1929.

History of Injury: Cut his hand with rusty axe which had been lying in the yard. Treatment of wound consisted of washing the hand and then putting iodine in wound. The wound was dressed by a member of the family until

it healed. This injury occurred three weeks before patient was admitted to hospital. Three days before admittance to hospital patient complained of cramps in the neck, back and shoulders; also had some pain on swallowing. Dr. H. was called and patient was sent to hospital November 26, 1929.

Examination at hospital revealed a boy fifteen years old, under-nourished, anemic, unable to visualize, throat, a spastic smile (*risus sardonicus*), opisthotonos, marked rigidity of abdominal muscles, exaggerated knee jerk, perfectly conscious, but talked with some difficulty due to inability to use muscles of mouth. Temperature on admittance 101°F., pulse 136, respirations 34, blood count 9950.

Course: On the following day this picture changed considerably; there were definite convulsions with marked general muscular spasm, voiding involuntarily, very restless, least noise caused convulsions. Patient's chief complaint was pain in the back. A very sick and restless patient.

On November 29, temperature, pulse and respiration began to come down, but patient developed pain in chest and cough. Still unable to take much fluid.

December 3, temperature, pulse and respiration about normal. Muscular spasm and pain about the same.

December 7, up in chair, still has spasm in muscles of back, on a soft diet. Discharged December 16, after twenty-one days in hospital; patient can walk with the aid of someone helping him.

Still muscle spasm in leg and back.

Examination in office a month later all muscle spasm gone.

Case II. M. H. File No. 1977, 1930. Referred by Dr. D. Girl, aged nine years. Admitted to hospital September 1, 1930.

History of Injury: Patient stuck splinter in foot August 27, in chicken yard, just four days before being admitted to hospital. Wound was treated by mother who was a very sensible woman and a graduate nurse. Wound healing nicely. On August 31, ate breakfast with difficulty. September 1, patient still complaining of inability to open mouth quickly; had pain in neck twice that day. Dr. D. called, patient brought to hospital on night of September 1, walked into hospital; was able to open mouth, but was very slow in doing it.

Examination showed no exaggeration of reflexes, no great amounts of stiffness of neck muscles. Patient was put to bed and no treatment given (a mistake). Temperature 99°F., pulse 88, respiration 20.

Course: At 6 A.M. patient had slight convulsion followed by pain in neck and back. Unable to open mouth. Blood count 11,700, polymorphonuclears 73 per cent. Urine negative, marked opisthotonos, spastic smile, light phobia, marked exaggerated knee jerk, a very restless and uncomfortable child.

Treatment was begun four hours later than it should have been. September 3, temperature 102°F., pulse 90, respiration 38. Fluids given by proctoclysis, 5 ounces every four hours. Patient in spasm most of time, spasm lasting for two minutes.

September 5, pain in chest, spasm lasting one minute. Unable to get anything but milk and water between teeth.

September 7, pain in chest and back, convulsion lasting about one minute, unable to open mouth.

September 8, temperature 102°F., pulse 108, respiration 28. Pain in back and chest. Still very rigid spine.

September 10, temperature 103°F., pulse 116, respiration 26.

September 12, temperature 100.4°F., pulse 108, respiration 30. Carbolic acid discontinued because of deep, smoky urine.

September 15, temperature, pulse, respiration about normal. Patient much more comfortable and up in chair.

September 16, patient comfortable but still unable to bend her back or open mouth ½ inch. Temperature 98°F., pulse 80, resp. 20.

Patient discharged on the sixteenth hospital day to go home. Patient still not able to walk.

A month later office examination failed to reveal any evidence of muscle spasm.

Case III. R. W. File No. 2397, 1930, City Hospital. Referred by Dr. K. Boy aged sixteen years. Admitted to City Hospital October 30, 1930.

History of Injury: Shot his hand with a blank cartridge, causing burn in the palm of hand. Seven days later he noticed some stiffness in muscles of jaws while he was at dinner. This soreness gradually became worse and he was admitted to the hospital October 30, nine days after the accident and two days after the first discomfort was noticed in the muscles of his jaw.

Examination: On admittance to hospital we found a boy sixteen years old, well nourished. He has a powder burn of the hand and some swelling. Also he has a vaccination for

smallpox that was ten days old and causing no trouble. The boy complained of soreness of the muscles of the jaw. Temperature 100.8°F., pulse 94, respiration 22. Blood count 11,600, 78 per cent polymorphonuclears.

Course: That night his temperature was 103°F., pulse 120, respiration 28. Patient complaining of stiffness of arms and very restless.

On October 31, patient very uncomfortable, photophobia, back muscles rigid, headache, general body stiffness, exaggerated knee reflexes. Temperature 103.6°F., pulse 110, respiration 26. Spastic smile, marked opisthotonos spasms.

November 1 and 2: No improvement.

November 3: Slight improvement, but still unable to take much liquid.

November 5: Patient still very uncomfortable, complaining of pain in back and neck, but temperature, pulse and respiration very nearly normal.

November 7: Still has great pain in back and slight spasms. Carbolic acid discontinued because of very dark, cloudy urine which showed a shower of casts.

November 9: Still suffering with back and neck and some spasms. Very rigid body.

November 10: Much more comfortable. Sodium amytal, which had been given the patient daily, discontinued.

November 12: Much better; some stiffness.

November 13: Carried before the hospital staff in rolling chair.

November 14: Discharged. Still has some limitation of motion due to disfunction of affected muscles.

This patient did get 1/8 grain of morphine on his first night in hospital, but no more. His urine cleared up within a few days.

CASE IV. E. B. File No. 1147, City Hospital, 1931. Aged eleven, admitted to hospital June 4, 1931.

History of Injury: On May 26 stepped on rusty wire in barn. Nothing was done that night. The next morning it was washed and iodine applied. On May 31, just five days after the injury, patient noticed he could not eat without some pain, especially when he tried to open mouth wide. June 1, he had difficulty in swallowing. Patient admitted to the hospital June 4.

Examination showed a healthy eleven year old boy, unable to open mouth or talk well. Tongue protruded between the teeth with difficulty. Examination of throat by specialist showed enlarged tonsils, but no acute infection. Chest normal. This patient had no other muscular rigidity with the exception of slight opisthotonus. All reflexes were exaggerated.

Course: This patient did not get intraspinal antitoxin, but other treatment was the same.

June 8: Patient much better, able to talk.

June 9: Patient allowed up on chair and for financial reasons was allowed to go home on June 10.

For two weeks after he left the hospital he was unable to walk, but at the end of the month there was no evidence of such spasm.

CASE V. J. J. File No. 1483, City Hospital, 1931. Referred by Dr. T., aged twenty-four. negro. Admitted to hospital July 12, 1931.

History of Injury: Colored man with no history of injury, but we removed a splinter from plantar surface of foot. History given by members of family is that five days ago he had sore throat and stiffness of muscles of neck and jaws which got worse until July 11, he began to have convulsions with white frothy sputum pouring from mouth. The convulsions occurred every hour and lasted from two to four minutes; he was conscious between spasms. The family on being asked why they had not brought him sooner said they were waiting for a brother to come who was out of town.

Examination: On admittance Sunday morning, July 12, the first impression was that patient was in hopeless condition, especially after a convulsion lasting for fully five to eight minutes. Spastic smile. Skin dehydrated. Restless, but partly conscious, a board-like rigidity of all muscles. Temperature 104°F., unable to get pulse, respiration 58, shallow and labored respiration. Blood count 10,350, 88 per cent polymorphonuclears. Urine four-plus albumin, cloudy.

Course: Full treatment was given, with no improvement. Pulse was never under 160. Convulsions continued. Patient died 1:30 A.M. July 13.

I believe this man could have been saved if he had been brought to the hospital five days before when the disease first manifested itself. This is a death due to ignorance; all the negroes believed he had been "conjured."

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FIBROMYOMA OF THE RECTUM

REPORT OF A CASE*

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HUNT[1] in 1921 reviewed the literature concerning myomas of the rectum, found 20 cases and added

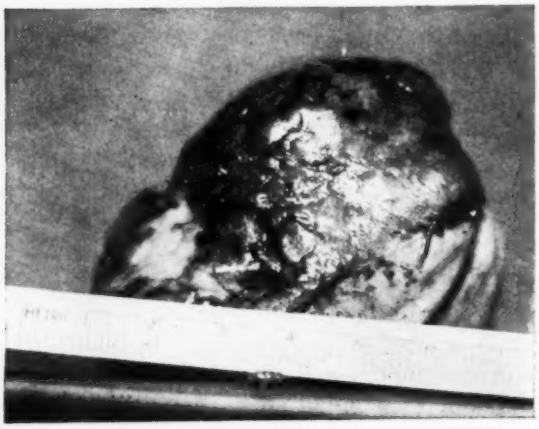

FIG. 1. Gross specimen illustrating character of tumor.

4 from the Mayo Clinic, 2 fibromyomas and 2 myomas. These benign tumors commonly give few signs until their increasing size causes obstructive symptoms. Their surface may become eroded and bleed and pain in the rectum is a common complaint of patients with these tumors.

These neoplasms are frequently pedunculated and present in the bowel lumen, although they may be extrinsic, and, as they grow larger, may decrease the caliber of the bowel.[2] They apparently originate in the muscularis mucosa or muscularis.

I wish to add another case report to those already in the literature.

CASE REPORT

Mrs. C. B., aged fifty-four years, presented herself for examination, complaining of long-standing constipation with increasing difficulty in moving the bowels; a sensation of a lump in her rectum; loss of 37 pounds in weight, and urinary frequency. Ever since a hysterectomy performed eight years ago, it has been necessary for her to take more and stronger laxatives. Within the last three months if her stools were not thin and watery, no bowel movement could be obtained. During this time she had a sensation of a lump or mass in her rectum. Walking or being on her feet increased this discomfort. About a year before examination, she had a severe hemorrhage from the rectum.

Examination revealed a firm pedunculated nodular tumor filling the rectum, attached along the left margin and posterior wall, from near the ampulla to within a few centimeters of the sphincter muscles.

Roentgenograms and fluoroscopic examination of the colon and rectum revealed a smooth pedunculated mass, apparently a benign tumor. A biopsy was performed through a proctoscope and microscopic examination of the tissue revealed a vascular fibromyoma. Other laboratory and physical examinations were unimportant.

Removal of the tumor was proposed. The patient entered the Wells County Hospital and was given a low residue diet. An ounce of liquid petrolatum was taken three times a day, as well as daily enemas. The patient was kept in bed and vaccination for peritonitis was performed according to the method of Bargen and Rankin.[3] After about a week of this regime, rectal examination revealed that the tumor had shrunk approximately a third in size and by inserting two fingers in the vagina, the tumor could be made to present at the anus.

With the aid of ethylene anesthesia, and with two fingers in the vagina and one in the rectum, the tumor was forced downward by gradual pressure, until it presented through the anal rings. The pedicle was clamped, cut, ligated, and the stump covered over with rectal mucosa.

The convalesence was uneventful and the patient left the hospital within ten days. Incontinence did not develop, and there was

* From the Caylor-Nickel Clinic. Presented before the Association of Residents and Ex-residents of the Mayo Clinic, Oct. 9, 1931, Rochester, Minn.

no sign of recurrence nine months after the operation. Much of the weight lost has been regained.

blood spaces were seen (Fig. 2). Dr. Broders has examined slides of the tumor and concurred in the diagnosis.

Fig. 2. Microscopic features of tumor include whorls of fibrous connective or muscle bundles, many thin-walled blood vessels and areas of degeneration. (× 100.)

The tumor at the time of its removal weighed 110 gm. and measured 7 by 6 by 4.7 cm. (Fig. 1). It was lobular and about two-thirds of its surface was covered by eroded, hemorrhagic mucosa. At one end of the tumor was a yellow to gray sloughing area, the site of the recent biopsy. Cut surfaces revealed interlacing whorls of grayish white fibrous tissue with a few yellow to gray areas of necrosis. The cut surfaces bulged after release of the intratumorous tension.

Microscopic examination revealed bundles of fibrous connective tissue and muscle as the chief structures that composed the tumor. There were areas of necrosis and many large

Surgical removal of tumors such as this is oftentimes a difficult technical procedure. If the growth is pedunculated and can be made to present through the anus, so a visualized conduct of the operation is possible, their excision is easy. But if the lesions are high lying and attached by a short pedicle, other procedures must be considered such as fulguration, pressure forceps, ligation, clamp and cautery excision, colotomy or resection.[4]

In this case, the preoperative preparation was a most valuable aid in the successful culmination of this operation.

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RECONSTRUCTION-ARTHROPLASTY OPERATION FOR THE HIP*

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IN a twenty-year association with Dr. Royal Whitman at the Hospital for Ruptured and Crippled, I have learned from observation and a considerable personal experience, that the reconstruction operation devised by Dr. Whitman has a very extensive application in certain difficult hip lesions. The essential features of the reconstruction operation are: (1) Removal of all obstructions from the acetabulum, such as the femoral head in ununited fracture through the neck, the dense soft tissue which fills the acetabulum in resistant cases of congenital dislocation of the hip, the numerous bony masses within the joint capsule and about the acetabulum in osteoarthritis, and so forth. (2) Remodelling of the neck of the femur or of the upper extremity of the femur into a form that approximates a femoral head and neck. (3) Osteotomy of the greater trochanter and implantation of this process lower down on the shaft of the femur to permit abduction of the limb.

FIG. 1. CASE III.

FIG. 2. CASE III.

The primary result of this operation is stability of the hip and the limb. Pain is usually greatly diminished. Mobility of the joint is a variable factor. In some cases there may result as much as 30 or 40 degrees of flexion, 20 degrees of abduction and the same degree of rotation. However, in the majority of reconstructed hips there

* From the author's service at the Hospital for Joint Diseases. Submitted for publication November 25, 1931.

is little motion, and not infrequently there is none. In addition, there is a strong tendency to a flexion and adduction de-

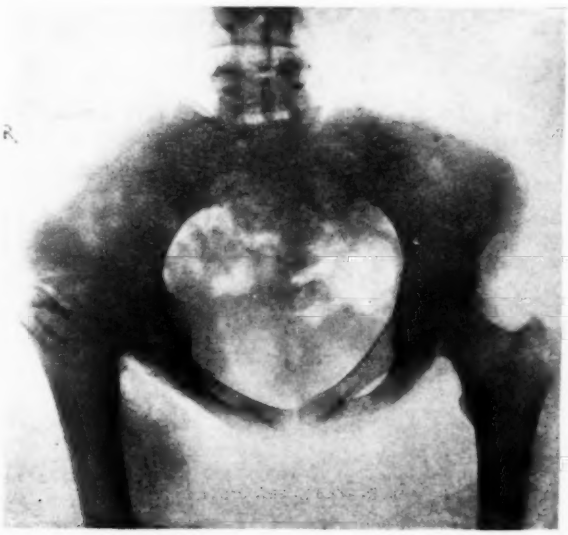

Fig. 3. Case v.

formity with an inevitable limp and consequent disability. The restricted motion adds to the disability. Discomfort in the hip is at times present to an annoying degree. When one recalls that the newly constructed head is bare of cartilage and rough, one realizes that a fibrous union is bound to occur, and, as in other joints with fibrous healing, pain, deformity and limited motion follow.

It therefore occurred to me that the reconstruction operation could be made more useful and more widely applicable by combining with it, on all occasions and at all ages, the advantages of an arthroplasty. The operation which I now perform is a typical Whitman reconstruction operation, but in addition I cover the newly formed femoral head with a double layer of fascia lata removed from the same or the opposite limb, and secured by sutures that pass through the substance of the adjacent bone.

Technique of the Reconstruction-Arthroplasty Operation

A half U incision is made over the antero-external aspect of the hip. The line of cleavage between the tensor fascia femoris and the gluteus medius muscles is found and the muscles are retracted laterally.

Fig. 4. Case v.

The capsule of the joint is now in view. With an osteotome the greater trochanter is severed from the femur. Care must be exercised to cut the trochanter at such an angle that there will be ample substance to form a head and fairly long neck. The trochanter and the pelvitrochanteric muscles are retracted. The capsule is incised and its edges are separated sufficiently to give a free exposure of all the structures of the hip. The next step in the technique depends upon the existing pathology. If the operation is for an ununited fracture of the neck, the femoral head is removed and the stump of the neck rounded off and filed to give a globular even extremity. If the condition is an osteoarthritis, the overgrown head is removed completely or nearly so, and the extremity of the neck or what is left of the head is made smooth with a chisel and file. If the operation is

for an ankylosis, an osteotomy is done in the vicinity of the joint line, the limb is everted and adducted, dislocating the upper extremity of the femur, which is remodelled into a head and neck. The acetabulum is enlarged with a reamer.

Fig. 5. Case vi.

Fig. 6. Case vi.

A 5 inch vertical incision is then made on the lateral aspect of the thigh beginning at the bottom of the original U incision. This exposes the fascia lata, from which a strip about 6 inches long and 4 inches wide is removed. The latter is placed in saline solution.

Following the suggestion of Dr. Campbell, two drill holes are made through the base of the newly formed femoral neck, one on either side. The fascia is placed over the femoral head and folded back on itself so that there are two layers of tissue between the acetabulum and the newly formed head. The fascia is secured to the femoral head by chromic catgut sutures that pass through the drill holes. It is further held down by a purse-string suture which goes around the neck. The femoral head is placed in the acetabulum and held there by abducting the limb.

The periosteum and some cortical bone equal in area to the greater trochanter are removed from the outer surface of the femoral shaft just below the neck. The greater trochanter is contacted with this raw surface on the femur and held there by numerous interrupted strong catgut sutures which pass through the periosteum over the trochanter, the periosteum and bony tissue lifted from the femur, and the aponeurosis of the vastus externus. The wound is closed in layers, interrupted catgut sutures for the deep tissues, chromic catgut for the deep fascia, plain catgut for the superficial fascia and silk for the skin, being employed.

Prior to the beginning of the operation moleskin adhesive plaster stickers for traction are applied to the leg from the ankle to a little above the knee. When the operation is completed a plaster-of-Paris spica bandage is applied, holding the limb in about 25 degrees of abduction, 15 degrees of flexion and slight inward rotation. The spica extends from the nipple line down on the affected side to near the ankle.

As there is always some oozing of blood after almost any hip operation of fair magnitude, it is helpful to insert a rubber tissue drain which can easily be removed after forty-eight hours.

The patient is returned to his bed, the head of which has been elevated on stilts about 15 inches high. The surface of the bed is rendered smooth and unyielding by inserting a large board between the spring and the mattress. Traction is applied im-

mediately; the amount depends upon the size and the tolerance of the patient. Five to 10 lb. of traction at the beginning are sufficient. This can be increased to 15 to 20 pounds in a few days.

The traction and plaster are left on for five weeks. Enough time must elapse to permit healing of the trochanter to the femur. The plaster is then removed and a swinging traction posterior splint is applied to the limb from the groin to the foot. Baking and massage of the hip and thigh and light passive movements are instituted. Active motion of the hip can be started a week later. Walking should be attempted at the end of about eight weeks after the operation.

The advantages of this procedure over the ordinary reconstruction operation are: (1) Pain is reduced to a minimum because the newly formed head is not only made as smooth as possible, but it is covered with a double layer of fascia. (2) The interposition of fascia between the head and acetabulum assures a fairly extensive range of motion in the hip joint.

Stability of the hip is as secure after the reconstruction-arthroplasty operation as after the simple reconstruction operation.

CASE REPORTS

Case 1. M. O., fifty years of age, was admitted to the Hospital on February 9, 1931 and discharged April 21, 1931. This man complained of pain in both hips, but more severe in the left. The pain in the left hip appeared about three years ago and was not preceded by any known injury or illness. The pain was followed by disability in walking. The symptoms increased and became so severe that the patient had to resort to the use of crutches.

The examination showed a bilateral osteoarthritis of the hips, worse on the left side. The man walked with great difficulty and with a marked limp. The left lower limb was flexed at the hip to 160 degrees, adducted 15 degrees and was in outward rotation. Rotation and abduction were completely restricted. There was a range of flexion from 160 to 125 degrees. The *x*-ray picture showed marked enlargement of the femoral head and acetabulum, numerous bony overgrowths on the femoral head and neck, and a reduction in the joint space. The right hip showed a similar lesion. As the left hip and lower limb were more painful and caused greater inconvenience than the right, it was decided to operate upon this joint first.

Reconstruction-arthroplasty operation on February 13, 1931. The technique used was that already described. The head of the femur was found to be enormously enlarged. Its surface was irregular and had numerous areas of atrophy of the cartilage. There was much overgrowth of bone. Most of the head was removed; the remainder was converted into a smooth globular extremity. The acetabulum was smooth except for some masses of fibrous tissue near its lower pole. A fascial flap was taken from the same thigh, doubled up and securely fixed over the new femoral head.

This man had an uneventful convalescence. The plaster spica was removed in a month. Two months after the operation there was a fair range of motion in the hip. The patient was fitted with a Thomas brace and ring and discharged.

Result. October, 1931: The globular extremity of the neck now fits very well in a roomy acetabulum. Clinically this patient has greatly benefited by the operation. He has practically no discomfort in the operated hip. There is a range of motion of about 70 degrees of flexion, 25 degrees of abduction, and fairly free rotation.

Case 11. H. P., seventy years of age, was admitted to the hospital on April 23, 1931 and discharged on July 14, 1931. Her chief complaint was severe pain in the right hip and total inability to walk or even stand. On February 8, 1931 she fell and broke her hip. The abduction treatment was given but could not be carried out efficiently because of lack of coöperation of the patient. The plaster spica was removed against advice by the surgeon taking care of her.

Examination showed that the patient was thin but in good general condition. She was unable to walk. Manipulation of the injured limb was very painful. The right lower limb was evidently shortened. It was in outward rotation, adducted, and flexed at the hip to 150 degrees. Measurement showed that the right lower limb was 1¼ inches shorter than the left. The *x*-ray picture revealed a fracture of the neck of the femur without union.

Reconstruction-arthroplasty operation was performed on April 24, 1931 under ethylene

anesthesia. The wound healed by primary union. The result seemed most satisfactory from every standpoint, but I had the same experience as her first physician. She was uncooperative and most refractory, refusing to help herself. The postoperative *x*-ray picture showed a satisfactory reconstruction. Finally this patient began to walk, but because of her disagreeableness was transferred to a convalescent home.

Case III. C. B., fifty years old, was admitted to the hospital on April 27, 1931 and discharged August 13, 1931. On January 22, 1931, he was struck by an auto and sustained a fracture of the left hip. He received indifferent treatment and the fracture did not heal.

Examination showed that he was markedly disabled. He just managed to get about with two crutches, but he could not bear weight on the left leg. He was thin, pale and in poor general condition. The left lower limb was 1¼ inches shorter than the right. It was adducted and rotated outward in an attitude characteristic of fracture of the hip. The *x*-ray picture (Fig. 1) showed an ununited fracture of the femoral neck with upward displacement of the shaft. As the fracture had not united in four months, it was unlikely to heal and an operation was advised.

The reconstruction-arthroplasty operation was done on May 1, 1931. Due probably to this man's poor general condition a mild wound infection with Staphylococcus aureus ensued. The postoperative routine was however not disturbed. The limb was placed in a swinging traction apparatus six weeks after the operation. At this time he had 30 degrees of flexion and 25 degrees of abduction. At the time he left the hospital he walked fairly well with one crutch. As he is now somewhere in Pennsylvania I have been unable to find out his present condition. The postoperative *x*-ray (Fig. 2) shows a satisfactory reconstruction. There is every prospect of a good result.

Case IV. H. L., fifty-three years of age, was admitted to the hospital on May 18, 1931 and discharged August 12, 1931. His chief complaint was pain in the right hip and knee and increasing difficulty in walking. On July 24, 1929 he was thrown from a second story window and fractured his right hip. When I first saw him, nearly two years later, he walked with a limp on the right side and with the aid of two crutches. The right lower limb was in marked outward rotation and moderate adduction. There was 1½ inches' shortening. The *x*-ray picture showed an ununited fracture of the neck of the right femur with extensive absorption of the neck and upward displacement of the femoral shaft.

On May 22, 1931 he had a reconstruction-arthroplasty operation. After removal of the femoral head the stump of the neck was found to be exceedingly small, hence the newly formed head was of very small dimensions. He stood the operation well but developed cardionephritic symptoms including dyspnea, irregular weak heart action and edema of the limbs. He had also a mild wound infection but without extrusion of the fascia. The cardiac lesion and the infection prolonged his stay in the hospital.

At present he is walking about fairly well. He has no discomfort in the operated limb. He still uses crutches. This is due to pain which he has in the left, unoperated, leg. The operated limb is in slight inward rotation. He is able to bear weight on it. There is unusually free motion in the hip, including flexion from 180 to 120 degrees, 25 degrees of abduction and marked inward rotation. A recent *x*-ray picture shows the newly formed head rather small for the acetabulum, but well within the upper part of this cavity.

Case V. M. R., twenty-five years of age, consulted me in 1925 for shortening of the right lower limb, a hollow back and difficulty in walking. At the age of two years she had pneumonia which was followed by an arthritis, probably suppurative, of the right hip. Shortly thereafter the parents found that the patient limped and that her right leg was shorter than the left. The deformity of the right limb gradually increased so that each year she had to increase the lift in the right shoe. At the same time the hollow in the lower part of her back increased.

When I saw her she walked with a marked limp. The right lower limb was flexed and adducted, rotated outward at the hip and shortened. There was a marked lordosis. There was also marked atrophy of the limb. The *x*-ray showed what I took to be a pathological dislocation of the right hip probably secondary to a suppurative epiphysitis or arthritis. I advised a reconstruction operation.

The patient left me and returned six years later, in June 1931, with all the symptoms aggravated. The deformity had become marked. The gait was very awkward. The

limb was fixed in an attitude of outward rotation, adduction of at least 15 degrees and flexion to 120 degrees. An *x*-ray picture (Fig. 3) showed complete disappearance of the right femoral head, flattening of the neck, upward displacement of the femur and apparently disappearance of the acetabulum. The advice to have her hip operated upon was accepted.

On June 9, 1931, a reconstruction-arthroplasty operation was performed. Very slight motion was found to be present. Contrary to expectation the femoral head was not absorbed. It was present but much flattened and elongated with overhanging edges. There was practically no neck. Its surface was smooth and covered with a tissue that looked like thin cartilage. There were numerous areas on the head from which the cartilage had disappeared; there were others from which fibrous tissue projected. The latter accounted for the ankylosis. The acetabulum was shallow and covered with a tissue that resembled abnormally thin cartilage. The ligamentum teres lay across the acetabulum and was greatly thickened. It was removed. The femoral head was reduced to about a fourth of its size. Enough bone was removed from its sides to somewhat resemble a femoral neck. The acetabulum was enlarged with a reamer. The newly formed head was then covered with fascia and the operation completed as already outlined.

This patient had an uneventful convalescence. The deformity was corrected. The postoperative *x*-ray picture (Fig. 4) shows a satisfactory reconstruction. At present (October, 1931) she walks about without any aid. The operated limb is parallel to the opposite leg. There is about 10 degrees of abduction and 40 degrees of flexion in the operated hip. The limb is painless and is rapidly improving in its function of weight bearing.

Case VI. I. S., six and one-half years old, came under my care on August 16, 1927 for suppurative arthritis of both hips. This child was well up to the age of nine months when, following a fall, the right hip became infected. Some short time later the left hip too became infected. When I first saw this child, at the age of two and one-half years, she had a low grade suppurative arthritis of both hips with huge abscesses in the thighs and fixation of both hips. The abscesses were evacuated and the limbs immobilized. In the course of several months the inflammation and the infiltration about the hips subsided and the sensitiveness disappeared. The child resumed walking. Both hips were ankylosed with complete destruction of the hip joints.

In May, 1931, the child had been free from symptoms for about three years. She had had two stretchings for correction of deformity at the hips without any recurrence of the inflammation. The hips were ankylosed (Fig. 5). It seemed very likely that the infection had completely disappeared. It was, therefore, deemed safe and opportune to re-establish at least one good hip and an operation was advised.

A reconstruction-arthroplasty operation was performed on the right hip on June 2, 1931. The technique already described was employed. Considerable difficulty was encountered in moulding the upper extremity of the femur into a head and neck. The acetabulum was filled with bone and soft tissue and had to be reformed by a reamer. The ultimate result from an anatomic standpoint was satisfactory. The postoperative *x*-ray picture (Fig. 6) shows a very fair hip joint.

Clinically this patient has a good result inasmuch as there is a painless range of motion in all directions. There is about 25 degrees of flexion, 15 degrees of abduction and rotation. Walking is not so good as it might be because of the fixation of the unoperated hip in flexion and adduction. Nevertheless, the child does walk very well and the operation can be considered successful.

Case VII. J. S., thirty-three years old, consulted me for increasing pain in the right thigh and an increasing limp. He was apparently well until six years ago when he began to experience a tired feeling in the right thigh. Pain and a limp supervened and gradually increased.

Examination showed a vigorous man who walked with a marked limp on the right side. The right lower limb was flexed, adducted and rotated outward at the hip. Inward rotation was completely restricted. An *x*-ray picture showed an enormous enlargement of the head of the right femur. The articular surface of the head was irregular. The joint space was greatly reduced. There was a marked overgrowth of bone at the upper part of the acetabulum. This man evidently had an extensive osteoarthritis of the right hip joint for which a reconstruction-arthroplasty operation was advised.

The patient was admitted to the Hospital for Joint Diseases on April 22, 1931; he was operated upon two days later and was discharged to the care of his family physician on May 4, 1931. The typical operation was performed. No technical difficulties were encountered. The femoral head was found to be about 2½ times the natural size. The articular cartilage both on the femoral head and in the acetabulum had numerous atrophic areas. In many spots there was complete disappearance of the cartilage. The femoral head was reduced in size until it was somewhat smaller than the normal. It was then thoroughly covered by a double layer of fascia lata. The limb was immobilized in a double spica which extended to the ankle on the right side and the knee on the left side. Traction was applied as soon as the patient was returned to his bed.

Ten days after the operation the patient, for financial reasons, insisted that he be discharged and that the rest of the postoperative care be given him at home by his family doctor. During his stay in the hospital he seemed well. He had very little postoperative discomfort, slight febrile reaction for a day or two, and no unusual complaints.

On the seventeenth postoperative day, one week after he got home, he suddenly experienced precardial oppression, became cyanotic and dyspneic and in a few hours expired, presumably from a pulmonary embolism. The postoperative *x*-ray picture of the hip showed a satisfactory reconstruction of the hip.

SUMMARY

The reconstruction-arthroplasty operation is an outgrowth of the Whitman reconstruction procedure. The technique employed is that described by Dr. Royal Whitman plus the use of a double layer of fascia lata to form a sort of bursa between the newly formed femoral head and the acetabulum. The fascia is secured to the femur by sutures passing around the neck of the femur and through drill holes in the base of the neck. It has so far been used for ununited fracture of the neck of the femur and osteoarthritis of the hip for which the Whitman reconstruction operation is chiefly intended. It has, however, also been applied in two cases of ankylosis of the hip in which this operation has the advantage over an ordinary arthroplasty in that the trochanter was displaced downward thus securing a fair range of abduction. The reconstruction-arthroplasty, which combines the technique of the reconstruction operation and hip arthroplasty, is indicated where either of these procedures is necessary, and is likely to prove more effective than either because of the additional technical features.

Seven patients, varying in age from six to seventy-five years, have been operated upon. There were 3 cases of ununited fracture of the hip, 2 cases of hypertrophic osteoarthritis of the hip, and 2 cases of ankylosis of the hip, one of two years' duration and one of twenty-four years' duration. The results, while not final because of the short time since the operation, are very encouraging.

PERIPHERAL VASCULAR SYSTEM IN THE CHRONIC ARTHRITIDES*

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THIS investigation is designed to determine the clinical status of the peripheral vascular system in the chronic arthritides. The cases have been classified as follows:

1. Osteoarthritis (syn.: hypertrophic or degenerative "type")
2. Rheumatoid arthritis (syn.: arth. deformans or atrophic "type")
3. Non-specific infectious arthritis (syn.: proliferative "type").

Osteoarthritis and rheumatoid arthritis we consider to be distinct morbid entities, having a clinical course and pathology peculiar to themselves. The third category is a heterogeneous group in which at present no further differentiation is possible, although the probabilities involve several types of streptococcus. I agree with Archer[1] and Cecil that the so-called arthritis of the menopause is osteoarthritis, but in addition we must emphasize the frequency of combined arthritis in this age group.

I shall not at this time attempt a comprehensive exposition of the pathology or symptomatology of these respective conditions, but confine myself to observations on the vascular mechanism, intending thereby further to differentiate the two distinct diseases from the heterogeneous group.

Two hundred cases of chronic arthritis were recently examined. Another hundred patients in whom the only or chief complaint was varicose veins were questioned for rheumatoid histories and examined for signs of joint pathology. Thirty-two patients with obliterative vascular disease (thromboangiitis obliterans and dysbasia angiosclerotica) were similarly examined and questioned. To supplement the clinical observations specimens of tissues obtained at the operating table from arthritic joints, and sections of limbs amputated because of obliterative vascular disease were also studied for the histopathologic appearance of the articular and periarticular vascular bed.

OBSERVATIONS

1. *Blood Pressure.* Most monographs which discuss the blood pressure readings in the chronic arthritides state that it is low or a low normal.[2] In our series this is true for only one category, rheumatoid arthritis. The contrary is true for osteoarthritis. In non-specific infectious arthritis the systolic pressures, while higher than the accepted average normals, are well within the limits of normal variation. The figures of Symonds, quoted by Fishberg,[3] were used as average normals. According to the latter, a systolic pressure above 150 mm. "is to be regarded as abnormal at all ages." In Table 1 it will be noted that in each age group over forty years the average systolic pressure in osteoarthritis is definitely hypertensive. The following figures will present a more accurate picture. Over 90 per cent of our osteoarthritics had a systolic pressure well above the average normal for their age group, and 61 per cent were above the 150 mm. limit. The apparent aberration in the forty to forty-four year age group of infectious arthritis is caused by the preponderance of females in the menopause age. The frequency of combined arthritis

* From the Service of Dr. Samuel Kleinberg, Hospital for Joint Diseases, and the Orthopedic Services of Dr. P. W. Nathan, Montefiore Hospital, and Mt. Sinai O. P. D. Read before the Section on Orthopedic Surgery, New York Academy of Medicine, November 20, 1931.

at this age is also a factor. The remarkably low pressure in rheumatoid arthritis coincides with the observations of others. In the appended graph (Fig. 1) these relationships will appear more obvious.

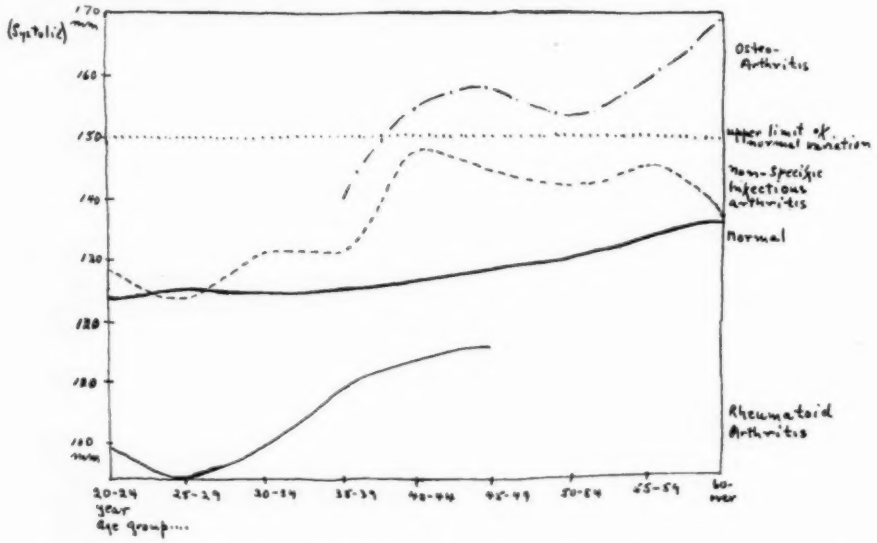

Fig. 1. Respective curves of averages for systolic blood pressure in three arthritides compared to accepted normals; 150 mm. marks upper limit of normal systolic variation; above this figure systolic pressure is considered abnormally hypertensive.

The tendency toward hypertension in osteoarthritis is intimately related to its symptomatology. Quoting Norris:[11]

> Muscular cramps especially in the lower extremities and at night is a common and annoying symptom of hypertensive people. The individual is often awakened by an intensive cramp in the calves excruciating in severity and relieved by active function, heat, or, if he can accomplish it, walking . . . The attacks are somewhat like those of intermittent claudication but the latter are induced by exercise and relieved by rest. The former occur during rest and are relieved by exercise . . .

With very little modification this picture will be familiar to anyone who has taken histories of moderately advanced cases of osteoarthritis. It is a frequent experience that in patients in whom osteoarthritis is accompanied by excessive blood pressure, relief from joint pain can follow sedative (as distinct from analgesic) medication.

2. *Obliterative Vascular Disease.* Thirty-two cases of obliterative vascular disease were examined in the Clinic for Vascular Diseases of Dr. Samuel Silbert at Mt. Sinai Hospital. No attempt was made in this study to differentiate between thromboangiitis obliterans and dysbasia angiosclerotica for two reasons: (1) differentiation in the middle age groups is difficult, and (2) the effect on the articular tissues is in both instances the same, that of a diminution of arterial blood supply. The average age of these patients was 42.2 years, a great majority ranging from thirty-eight to fifty. Of these only one presented a sign of osteoarthritis and this was an asymptomatic Heberden node. Four cases offered histories of previous transient rheumatic pains in joints other than those involved by the present complaint.

To correlate our arthritic patients with the foregoing observation the dorsal pedis pulsation was recorded in most of the examinations. In osteoarthritis the pulse was invariably of an intensity within normal range. In rheumatoid arthritis, however, a tendency toward diminution was noted progressing in most instances with the advance of the disease process. In its later stages, an absence of the dorsalis pedis pulsation was not infrequently ob-

served. On the Orthopedic Service in Montefiore Hospital there are always several cases of end-stage rheumatoid

Table 1

Age		Systolic	Diastolic	Pulse Press.
20–40	Normal	124.2	80.5	43.7
	Osteo-arth.			
	Rheumatoid arth.	100.0	70.0	30.0
	Infec. arth.	128	63.0	65.0
25–29	Normal	125.5	81.5	43.0
	Osteo-arth.			
	Rheumatoid arth.	95.0	70.0	25.0
	Infec. arth.	124.0	78.0	46.0
30–34	Normal	125.1	82.3	42.8
	Osteo-arth.			
	Rheumatoid arth.	100	68	33
	Infec. arth.	132	79	53
35–39	Normal	125.3	83.3	42.0
	Osteo-arth.	140.5	88.0	52.5
	Rheumatoid arth.	110	60	50
	Infec. arth.	130.8	74.5	56.3
40–44	Normal	126.4	84.0	42.4
	Osteo-arth.	155.0	81.8	73.2
	Rheumatoid arth.			
	Infec. arth.	148.0	77.0	71.0
45–49	Normal	128.2	84.7	43.4
	Osteo-arth.	156.8	88.3	68.5
	Rheumatoid arth.	115	80	35
	Infec. arth.	144.4	83.1	61.3
50–54	Normal	130.2	85.7	44.3
	Osteo-arth.	152.4	89.6	62.8
	Rheumatoid arth.			
	Infec. arth.	141.2	76.2	65.0
55–59	Normal	133.5	86.8	46.7
	Osteo-arth.	158.0	86.6	71.4
	Rheumatoid arth.			
	Infec. arth.	145.0	85.0	60.0
60–over	Normal	135.2	86.9	48.3
	Osteo-arth.	169.3	91.9	77.4
	Rheumatoid arth.			
	Infec. arth.	137.5	76.2	61.3

arthritis in which vascular obliteration is so far advanced that one or even several extremities have become gangrenous. When this occurs the tissue necrosis is general in the distal portion of the limb. It is not a discrete closure of the vessels to the hallux, but the entire foot or hand shows evidence of the change.

The earliest manifestation of this process is atrophy and discoloration of the skin, a result of insufficient circulation to the superficial tissues. In most instances this atrophy is self-limited and remains at a constant level for many years. However, later in life a further decrease in the patency of the vessels from any added cause, such as senile arteriosclerosis, crosses the margin of vascular sufficiency and gangrene ensues. There is undoubtedly in this composite picture of vascular obliteration in rheumatoid arthritis a neurotrophic factor, but the diffuse musculofascial fibrosis which is the effective morbid lesion plays the overt part.

3. *Varicose Veins.* In each case of arthritis the presence or absence of varicosities was noted. Seventy-seven per cent of the osteoarthritics presented varicose veins in the lower extremities. In only 28 per cent of the infectious group could they be found. These figures were compared with 100 cases from the Varicose Vein Clinic of Dr. I. S. Tunick at the Hospital for Joint Diseases. Fifty-three of these were well within the osteoarthritic age group, that is, forty years or over. Of these, about 50 per cent showed signs of the disease, 18 presenting Heberden nodes. The body habitus in patients over forty suffering from varicosities or osteoarthritis is very frequently similar, that is obese, sthenic, and characterized generally by a flabby musculature. In other words, the constitutional factor which predisposes the body to osteoarthritis likewise predisposes it to varicose veins. That the frequent presence of venous stasis occasioned by the varicosities bears a relationship to the pathology of osteoarthritis will be shown later.

4. *Histopathology.* Osteoarthritis. Sections of bone show no changes in the blood vessels. The trabeculae and marrow look well nourished. Only when erosion of the cartilage has exposed bone does any change appear in its structure, and then, in the area adjacent to the gap in the articular plate there is formed rather well demarcated granulation tissue. In the soft tissues, however, there is considerable change. The hypertrophied synovial and subsynovial tissue is decidedly hypervascular, with numerous dilated blood vessels. Perivascular accumulations of leucocytes are

frequently visible especially in the intra-articular portion where internal trauma has caused an appearance of aseptic inflammatory change. The general picture is that of vascular congestion or hyperemia of the hypertrophied tissues.[4] In those fields in which few vessels are found the fatty degeneration so characteristic of the excessively hypertrophic synovia is most evident. The easy formation of osteophytes on the articular surfaces at sites of static internal trauma is a consequence of the local hyperemia. Pathologic bone growth, whether callus or osteophyte, depends upon tissue injury and local blood supply,[5,6,7] and both conditions are favorably present in these joints.

Rheumatoid Arthritis. Sections taken at Wilson capsuloplasties were examined. These were cases in which the febrile stage had long since subsided, so that very little manifestation of any active infectious process which may have existed was present. The specimens were characterized mainly by soft tissue fibrosis in which the vessels were included, and by bone atrophy. No difference is perceptible between sections of articular bone in rheumatoid arthritis and those in obliterative vascular disease, except in degree of atrophy. The picture in the soft tissues was one of hypovascularity, with actual decrease in the size and number of the smaller vessels.

DISCUSSION

A. E. Garrod in 1907[8] with many others before and since recognized the fact that the term chronic arthritis connotes a group of diseases having in common only their localization of symptoms in or near the articulations. This is far different than the usual conception which classifies them merely as "types" of a single morbid process. The distinctions are pathologic as well as clinical. In the above sections a series of observations are recorded noting the status of the peripheral vascular system in each of these conditions. In osteoarthritis the blood supply to the extremities is characterized, generally speaking, by a sluggish venous circulation. In rheumatoid arthritis there is present a diminished arterial circulation.

The pathology of these respective diseases is what one could consistently expect from the observed vascular situation. Pearse and Morton,[7,9] Jaffe,[6,10] Muller,[5] in recent years, and others before them have shown that the physiology of bone is remarkably sensitive to blood supply. The density of the bone ends and the easy formation of exostoses near the articular surfaces at sites of internal static trauma is deducible from the presence of venous congestion in osteoarthritis.

In rheumatoid arthritis, with its gradual decrease in vascular patency, one would anticipate the marked atrophy of bone and absence of osteophytes which is actually found. We must emphasize here that the knobby, deformed hand which is seen in this disease is caused by periarticular swelling, and the subluxation of heads of metacarpals and phalanges consequent to soft tissue contraction rather than exostosis.

It cannot be said that the vascular system is an etiological factor in either of these conditions, but we wish to demonstrate that the progress of deformity, the symptoms and the disability are directly influenced by the state of the circulation and this is an integral part of the disease processes. The practical application of these facts to therapy must be obvious. The necessity for the prolonged use of measures intended to adjust the blood supply to the extremities is an important part of any therapeutic regime. In the chronic arthritides, as in many other illnesses of insidious development, it is the usual fact that the patient is not seen by the doctor until the process has become well advanced. Eradicating an etiological factor is by that time only a part of the necessary treatment. Rehabilitation of crippled limbs is equally urgent. It is here that the vascular status requires our careful consideration.

SUMMARY

1. The systolic blood pressure in osteoarthritis is, in most cases, considerably above the normal for each age group. In rheumatoid arthritis it is definitely subnormal. In non-specific infectious arthritis there is no deviation from normal variations.

2. Gradual occlusion of the peripheral arteries is a characteristic observation in rheumatoid arthritis. In advanced cases this may lead to gangrene of the distal part of the extremities.

3. Osteoarthritis is a very uncommon finding in obliterative vascular disease.

4. Varicosities occur in a very large proportion of patients suffering from osteoarthritis. The latter, conversely, is frequently found in patients in whom the chief or only complaint is varicose veins.

5. The histopathologic appearance of the articular and periarticular tissues is consistent with these clinical observations and is logically deducible.

6. Rheumatoid and osteoarthritis are further differentiated by their respective vascular changes into two distinct diseases, leaving non-specific infectious arthritis as a third heterogeneous group.

I wish to record my appreciation to Dr. Samuel Silbert and Dr. I. S. Tunick for permission to use the material available in their respective clinics, and to Dr. H. L. Jaffe, Director of Laboratory at the Hospital for Joint Diseases for his kind assistance with the pathological studies.

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THE ROLE OF SYMPATHETIC NERVE SURGERY

IN VASCULAR DISORDERS OF THE EXTREMITIES*

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INTRODUCTION

SURGERY of the sympathetic nervous system is largely a product of the past ten years. While it is true that as early as 1896 cervical sympathetic ganglionectomy was performed on a large scale for various ill-defined disorders such as epilepsy, tic douloureux, migraine, glaucoma and exophthalmic goiter, yet the procedure was soon abandoned by its most ardent early supporters. Probably the chief reason for this decline in interest was dependent upon the fact that the procedure was applied empirically without sufficient experimental data to guide its usage. The reports of Royle and Hunter[1] appearing in 1924, upon the relief of spastic paralysis by ramisection, stimulated neurological investigators generally to pursue by laboratory and clinical experimentation some of the more fundamental concepts of sympathetic nerve surgery. From these researches arose the principles for the successful treatment of certain diseases heretofore considered to be incurable.

These new therapeutic possibilities were received enthusiastically by the profession. Like almost all other new advances in treatment, we are finding that our original enthusiasm was over-abundant. Some of our early expectations have not been fulfilled, while others have been exceeded by the light of further evidence. Even at the present time, we are unable to evaluate correctly the effects of sympathectomy upon certain diseases, but in general, experience has quite thoroughly established the operative indications and the probable results.

We shall consider in this paper only the effects of sympathetic nerve surgery in the treatment of vascular disorders (arterial) of the extremities.

Before proceeding with the clinical consideration of this topic, let us for a moment review the anatomical relationships between the sympathetic nervous system and the arteries of the extremities. The caliber of the arteries is in general dependent upon the state of contracture of their muscular walls. The tone of this muscular coat is supposed to be dependent upon nerve impulses passing over two sets of fibers: (1) the vasoconstrictor; (2) the vasodilator. The vasoconstrictor impulses to the upper extremities are carried through the cervicodorsal sympathetic chain, and to the lower extremities through the lumbar chain. These impulses travel by way of the white rami communicantes as preganglionic fibers to the regional sympathetic ganglia. The impulses are then carried by postganglionic gray fibers to the spinal nerves to be distributed with them in the somatic, muscular and cutaneous areas. In the upper extremities, there is a direct sympathetic supply to the large vessels, which does not pass through the spinal nerves. Perhaps, also, it is well to mention the secondary sympathetic system along the vessels as proposed by Braeucker.[2] Thus, to destroy effectively the vasoconstrictor mechanism to the arteries of the part, it is necessary to section the regional gray rami or the preganglionic or postganglionic fibers before they enter the spinal nerves for their final distribution. Section of the rami, if completely done, would of itself destroy central vasoconstrictor connections, but the danger of missing some of them led Adson and Brown[3] to introduce ganglionectomy with trunk resection as the operation of choice

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when attempting to abolish regional sympathetic action.

The presence of a neurological vasodilator mechanism is still imperfectly understood. Whether the dilatation of the arteries, after removal of the vasoconstrictor tone, is an active or passive phenomenon is still a mooted question.

GENERAL CONSIDERATION OF VASCULAR DISORDERS

It is desirable from the standpoint of treatment to classify loosely arterial disorders involving the extremities into two main groups: (1) Those of the vasomotor, or functional nature, of which there are two types: vasoconstrictor disturbances (Raynaud's disease, arthritis deformans, scleroderma, etc.) and vasodilator disturbances (erythromelalgia); (2) those of organic disease of the arteries (Berger's disease, arteriosclerosis, thrombosis and embolism). Actually, this classification is inexact, in that the first group may be associated with organic changes in the vessels themselves, and the second group may contain varying degrees of vasomotor overactivity. As a working basis, however, the classification is feasible.

So far as we know, the only beneficial effects of depriving the extremities of their vasomotor mechanism in the treatment of vascular disorders is the increase of blood supply with its resulting increase of temperature and nourishment, due to the dilatation of the arteries, and the abolition of the sweating mechanism which prevents heat loss by evaporation. Obviously, if symptoms of the disorder are primarily due to ischemia from vasomotor overactivity (spasm), abolition of the vasomotor mechanism to the part should be highly beneficial in that more blood will be carried to the part. On the other hand, if symptoms result from organic disease in the walls of the vessels themselves with little or no vasomotor overactivity in the remaining vessels, no beneficial results would be expected from sympathectomy.

The prime considerations, therefore, in the proper selection of patients for sympathetic nerve surgery are: first, to determine the degree of ischemia; second, to differentiate between organic and spastic vascular disturbances; and third, to determine the probable clinical effect of removal of the regional sympathetic nerve supply.

METHODS FOR DETERMINING THE DEGREE OF ISCHEMIA

Ordinarily, by palpation alone, one can determine the degree of ischemia fairly accurately. When the involved extremity is colder to the touch than a normal extremity under the same environment, and when it is clammy and moist, ischemia of considerable degree may be assumed to be present. For a more accurate determination of the degree of diminished blood supply, calorimetric or surface temperature studies should be made. The Stewart calorimeter is a valuable instrument in determining the local heat production and radiation of an extremity. It is time-consuming to use, however. For practical purposes, the skin temperature studies are quite sufficient to determine the degree of ischemia. It has been shown that the surface temperatures compare fairly closely with the deep temperatures, under similar environmental conditions. There are several convenient, accurate, but expensive, thermocouples on the market. For clinical work, we have found the skin temperature thermometer to be perfectly satisfactory. It is accurate, simple and reliable. Temperature readings should be made at several points on the involved parts and comparison made between readings on the uninvolved parts. (These temperature readings should be checked several times under as nearly constant environmental conditions as possible.)

DIFFERENTIATION OF ORGANIC AND SPASTIC VASCULAR CONDITIONS

The methods so far in use for the determination or organic vascular disturbances are based upon indirect evidence obtained by the temporary abolition of the vasomotor control to the parts. After vaso-

spasticity has been eliminated by one of various methods, the resultant ischemia is assumed to be due to lesions within the arteries themselves.

Several satisfactory methods are available for the temporary abolition of vasomotor control. For the past two years, we have used acetyl choline hydrobromide, given intramuscularly in doses of from 100 to 200 mg. This drug is a powerful vasodilator, and may be administered repeatedly without detrimental effects upon the patient. We have found that the postoperative skin temperatures correspond very accurately with the skin temperatures taken during the preoperative test with acetyl choline. The technique of performing the test is essentially the same as used in all other methods. Surface temperatures are recorded prior to the administration of the drug, care being taken to keep the environmental temperature constant. After administration of the drug intramuscularly, temperature readings are made at fifteen minute intervals over a period of one hour. Mouth temperature readings are made, although this is probably unnecessary, inasmuch as we have never found a general febrile reaction to the drug. The number of degrees of rise in the surface temperature may be taken as the approximate vasomotor index. It should be pointed out that in all vasospastic conditions of the extremities, particularly Raynaud's disease, scleroderma, and arthritis deformans, periods of exacerbation of the ischemia vary from hour to hour, particularly after stimulation with change of environmental temperature and emotional excitement. To obtain a true vasomotor index, it is advisable to record temperatures during the periods of angiospasm, so that the most severe ischemia may be recorded. In conditions where angiospasm predominates, the rise of surface temperature may be as high as 12° to 14°C. after the administration of acetyl choline.

It is impossible with our present knowledge to say how high the vasomotor index should be before sympathetic nerve surgery is indicated. As a working basis, we have set the lower limit as 5°C. rise in surface temperature after the administration of acetyl choline.

Another method for determining the vasomotor index is the "fever test" devised by Adson and Brown.[3] We used this test originally and abandoned it chiefly because of the discomforting reactions, often alarming, which were produced in the patients.

Another satisfactory method for determining the degree of vasospasm is by the administration of a spinal anesthetic. We have had no experience with this method as a diagnostic procedure, feeling that it is entirely too drastic to warrant general use.

Another excellent method is the injection of the peripheral nerves supplying the area under observation with novocaine, as advocated by Lewis.[4] We have used this method in connection with the acetyl choline test and have found the degree of temperature rise with both methods to be essentially the same.

DETERMINATION OF THE PROBABLE CLINICAL EFFECTS OF SYMPATHECTOMY

The determination of the vasomotor index is perhaps the most accurate method for determining the amount of relief which may be expected from sympathetic nerve surgery.

A very reliable adjunct is often obtained from the statements of the patients themselves following temporary abolition of vasomotor control by one of the methods just mentioned. If the patient is symptomatically improved following repeated doses of acetyl choline, provided, of course, the vasomotor index indicates satisfactory response, we feel much safer in recommending sympathectomy than had this symptomatic improvement failed to appear. This is particularly true in cases of arthritis and Berger's disease. If vasodilatation has been known to occur, as indicated by surface temperature studies, and the patient has had no indication of symptomatic relief, then one must be very conservative in recommending surgery.

It might be pointed out at this time that the more conservative methods for producing vasodilatation have a distinct place in therapeutics of these borderline vasospastic disturbances. The "fever test" has been used very successfully in the treatment of Berger's disease, arthritis deformans and various other peripheral vascular disorders by the Mayo Clinic group. We have used acetyl choline in the same type of cases with very satisfactory results. Even cases of impending gangrene, of the arteriosclerotic and diabetic types, have often been symptomatically improved, and in one case of arteriosclerosis, the gangrenous process was completely arrested by the use of this drug.

RAYNAUD'S DISEASE

From the day of Raynaud's original report in 1862 until the present time, this disease has been considered to be due to an overactivity of the vasomotor mechanism without demonstrable changes in the vessels. Naturally, with the advent of sympathetic nerve surgery, this condition should be one of the first to be attacked. Adson[5] was the first to report the successful treatment of Raynaud's disease by cervicodorsal and lumbar sympathectomy. The relief of symptoms was complete and had been permanent to the time of his last report. Similar beneficial results have been reported by other observers.[6]

Thomas Lewis[4] was the first to question the theory of vasomotor origin for this disease. He considered the symptoms to be due to spasm of the vessels from causes other than vasomotor overactivity; that is a lesion within the wall of the vessel itself. His researches cast considerable doubt upon the curative value of sympathectomy in the treatment of this disease.

We have treated five patients with typical Raynaud's disease during the past two years. The relief of symptoms in the lower extremities has been complete in all patients thus far treated. In only one of the five patients, however, have symptoms been completely relieved in the hands. One patient has lost all the fingers of the right hand, three of which became gangrenous following the cervicodorsal sympathectomy. In the other three patients with recurrence of symptoms, the attacks have been precipitated by a sudden change to cold weather, or by handling ice or cold objects. The severity of the attacks, however, has been lessened in each instance, and the soft tissue changes in the fingers have entirely disappeared.

Some may argue that the operative procedure in these cases was not completely done. In each instance, the entire trunk from above the inferior cervical ganglion to below the second dorsal ganglion was removed. In the patient who had recurrence of gangrenous fingers, the entire chain from the superior cervical to the third dorsal was removed in two stages. Also, this patient was subjected to multiple periarterial sympathectomies. In spite of the radical abolishment of all known pathways for vasomotor activity to the arm, the patient continued to have severe symptoms of Raynaud's disease with an ultimate loss of digits. It seems rather paradoxical that the disease should be cured in the feet and not cured in the hands. Raynaud's disease, however, is primarily a disease of the upper extremities, although the lower extremities may be and are usually involved to some extent. This difference in the severity may be responsible for the discrepancy. On the other hand, the sympathetic nerve supply to the upper extremities is much more complex than to the lower extremities. It is quite possible that due to gaps in our present knowledge, we are failing to desympathectomize the upper extremities but have succeeded in the lower extremities. Perhaps again the disease is not primarily vasomotor. If such were the case, our failure would be readily explained were it not for the fact that the feet apparently have been cured entirely in all reported cases.

We do not wish to imply that sympathectomy is not indicated in the treatment of this condition. It offers, perhaps, the best

method at our disposal. While the disease is not "cured" in the hands, and in some advanced cases not even arrested, the improvement in symptoms more than justifies the procedure.

THROMBOANGIITIS OBLITERANS

This malady correctly belongs in Group 2 in our classification of vascular disorders, because the underlying pathological process is an organic disease of the arterial walls, affecting chiefly the end arteries. If these obliterative processes were entirely responsible for the ischemic symptoms in the parts, sympathetic nerve surgery would be clearly contraindicated. As a matter of actual observation, however, the ischemic manifestations are due partly to other factors than the obliterative processes. Some degree of vasospasm of the collateral circulation is always present. The amount of angiospasm can be measured only by determining the vasomotor index as already described. If one can demonstrate, after the vasomotor mechanism has been temporarily abolished, that the part becomes warm, that the surface temperature is increased, and the patient is symptomatically relieved following the test, then permanent removal of the vasomotor tone may be considered to be indicated. It must be kept in mind, however, that the relief afforded in this type of case is symptomatic and probably will not greatly affect the course of the disease within the arterial walls. Ischemic pain is the predominating symptom of the malady. If this factor can be controlled by one of our various methods for attacking the sympathetic nerve supply to the vessels, the result will justify the procedure.

In our experience, properly selected cases of Berger's disease treated by sympathetic ganglionectomy have given very gratifying results. Relief of the incapacitating pain has been striking. Even though amputation later becomes necessary, it can be done at a lower level than would have been possible without a previous sympathectomy. In extremities where there has not been impending gangrene or indolent ulcers, the total relief of symptoms has been maintained for many months. Furthermore, we have seen cases with cellulitis, ulcerations, and indolent ulcers completely heal following sympathectomy.

ISCHEMIC CAUSALGIA

The same line of reasoning as applies to Berger's disease applies in cases of this type. If the main vessel to a part is obliterated and the collateral circulation is insufficient, removal of the vasomotor tone should result in more adequate blood supply to the part; hence, relief of symptoms. We have had one very interesting case to illustrate this situation. The man was shot through the second portion of the axillary artery, and he suffered excruciating pain in the arm, uncontrollable by any means at our disposal. Abolition of the vasomotor tone by acetyl choline gave not only a satisfactory vasomotor index but marked relief of symptoms. Removal of the regional sympathetic nerve supply resulted in a total permanent relief of ischemic pain. We have had no experience in treating causalgia secondary to nerve involvement. Theoretically, at least, such cases would not respond satisfactorily to sympathectomy.

SCLERODERMA

This unusual skin disease is characterized by marked thickening and pigmentation of the skin with atrophy of the soft tissues about the lesions. It usually involves the hands and feet but may involve other parts of the body. The involved parts are usually cold, clammy and show definite evidence of ischemia. This disease often accompanies vasospastic disturbances like Raynaud's disease, thromboangiitis obliterans, chronic deforming arthritis, causalgia, etc. In cases of this type sympathectomy has given relief of symptoms with disappearance of the skin lesions. The completeness of relief, of course, is dependent upon the underlying cause of the deficient

blood supply. The same careful studies of the vascular supply to the part are required as in the other vasospastic disorders.

CHRONIC DEFORMING ARTHRITIS

There is a certain group of young patients suffering from arthritis, who present evidence of marked ischemia as manifested by cold, clammy, sweaty, and mildly cyanosed extremities. These symptoms usually occur in the so-called arthritis deformans which is chiefly periarterial in type. The joints are usually painful, swollen and tender. There is marked atrophy of the muscles with an early tendency toward contractures. Pain is the predominating symptom. Rowntree and Adson[7] applied the principles of sympathetic nerve surgery in the treatment of this type of case with brilliant results. The application of external heat and the institution of various physiotherapeutic measures to increase the blood supply to the involved parts have been the "ages old" methods of treatment. After all, sympathectomy is merely an elaboration of the older methods by providing a constant increase of temperature and a more adequate blood supply to the parts involved. Assuming that the arthritic patient presents symptoms of ischemia and a favorable vasomotor index, the following additional factors must be thoroughly considered in order to secure the best results:

1. There should be no mechanical hindrance to joint motion such as bony proliferation with spur formation, or ankylosis.
2. Articular surfaces should be clear.
3. Peripheral vessels should be comparatively free from arteriosclerosis.
4. The febrile reaction must have subsided.
5. All other forms of medical treatment should have failed to arrest the disease.

In dealing with arthritis, the same care for the selection of the operative case must be followed as in all other vascular disorders. Perhaps, it is even more important to depend upon a statement of the patient regarding symptomatic relief afforded by repeated injections of acetyl choline. It is very difficult at times to determine whether the pain is due to ischemia or to contractures of tendons, ligaments, and joint capsules. Unless the pain is of ischemic origin, sympathectomy will be of little avail. On the other hand, if the pain is purely of ischemic origin, prompt permanent relief may be experienced. The results in the treatment of arthritis are of the best in the field of sympathetic nerve surgery according to our experience. One may expect good results only, however, if their cases are selected with diligent care.

Before closing, there are two other conditions that at times respond well to sympathectomy and deserve mention. Slowly healing stumps with ulceration are often benefited by vasodilatation following sympathectomy. Acetyl choline in repeated large doses may occasionally serve without an operation. Cases with paralytic sequelae of anterior poliomyelitis may be materially helped by sympathectomy. If the epiphyses of the long bones have not closed, the increase of blood supply following sympathectomy will bring about a better development of the afflicted members.

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IMPROVED METHOD OF OPERATION FOR UTERINE MALPOSITION*

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THERE are 127 different operations for malposition of the uterus of which none is perfect and some are limited in use; with this in mind we have devised a method of operation that has anatomically and clinically fulfilled our desires toward the ideal.

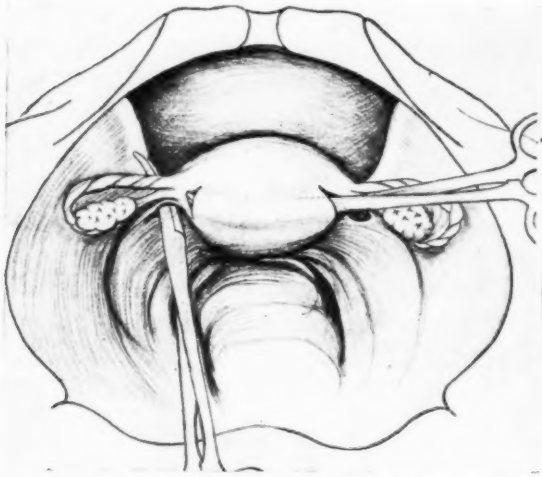

FIG. 1. An opening is made through broad ligaments. Incisions are made through serous layer of uterus. Canal is made between incisions with a mosquito or Kelly forceps.

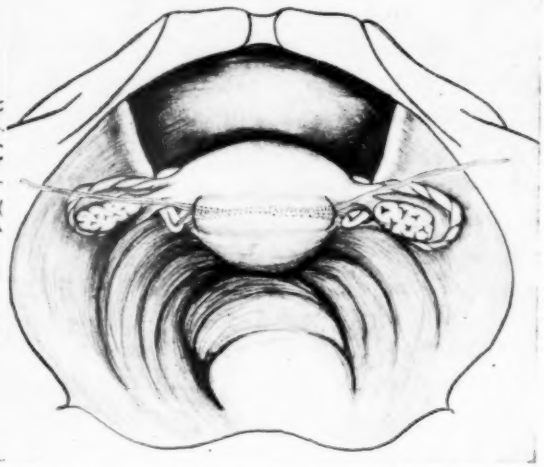

FIG. 2. Round ligaments are pulled through broad ligaments. Catgut is placed through loop of each round ligament and canal to opposite side.

Such operations as the Olshausen, Alexander, Baldy-Webster, Coffey, Gilliam, Wiley, Kelly, Mayo, Crossen, Barrett, Simpson and Montgomery are some of the many devised for this condition. Some of the objections to these operations are:

1. Recurrence of primary condition.
2. Intestinal obstruction.
3. Postoperative adhesions.
4. Difficulty of correct performance.
5. Postoperative hernia.
6. Silk stitch sinus.

We wish to change the term suspension to that of reconstruction and correction. When one studies the anatomy of the uterus and the causes of its displacements and then does one of the classical suspension operations he does do a suspension or partial suspension but the term defeats the true purpose of such operation, which in reality is a reconstruction and correction. This operation is a reconstruction of anatomical support with replacement of pelvic viscera in their normal positions.

The round, broad and uterosacral ligaments and the pelvic floor support maintain the uterus in its proper position and in relation to other pelvic organs. A second degree tear including the pelvic fascia and muscles weakens the pelvic floor retarding the normal involution of the uterus by disturbing the round ligaments or uterosacral ligaments or both, allowing a vertical or postvertical axis of the uterus with intra-abdominal pressure on the anterior surface of the uterus favors displacement which is usually posterior.

* Submitted for publication October 27, 1931.

INDICATIONS

The method of operation which I have devised is indicated in any form of uterine displacement and prolapse except in an acute inflammatory condition.

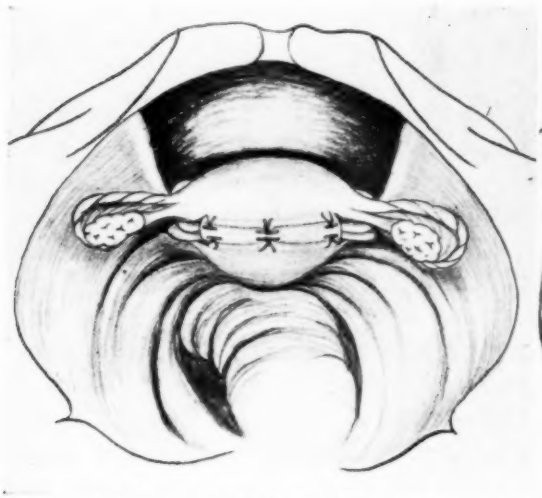

Fig. 3. Round ligaments pulled to midline and sutured.

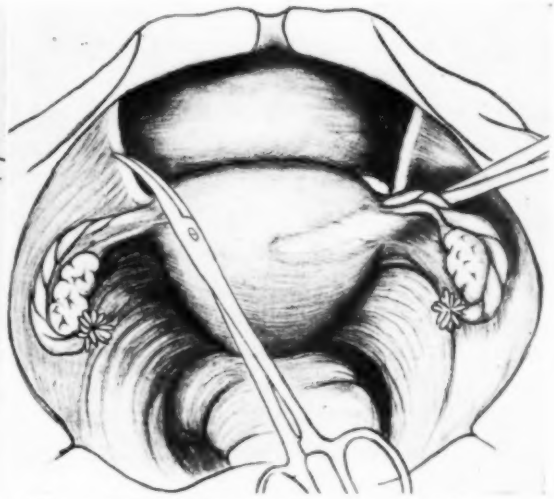

Fig. 4. Canal is formed with a mosquito forceps pushed through anterior layer of broad ligament, along posterior wall of uterus between serous and muscular layers.

TECHNIQUE

First Step. The cause is removed. This may include a dilatation and curettement, a cauterization of the cervix, repair of the pelvic floor, or the removal of part or all of one or more of the pelvic organs.

Second Step. The fundus of the uterus is lifted into position. A curved Kelly forceps is pushed from behind forward through the broad ligament close to the uterus under the tube and under the round and ovarian ligaments. A loop of the round ligament is brought back through the opening in the broad ligament. This is repeated on the opposite side. Vertical incisions are made through the peritoneum just medial to the openings in the broad ligaments or just below the level of attachment of the ovarian ligaments. A curved Kelly or mosquito forceps is pushed from one opening to the other between the serous (peritoneum) and muscular layers

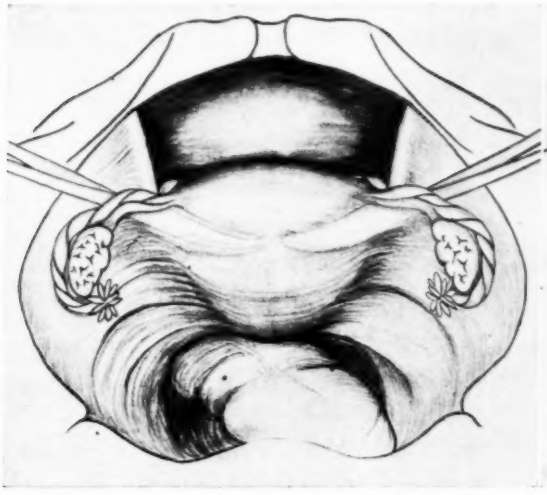

Fig. 5. Round ligaments pushed into canal to midline.

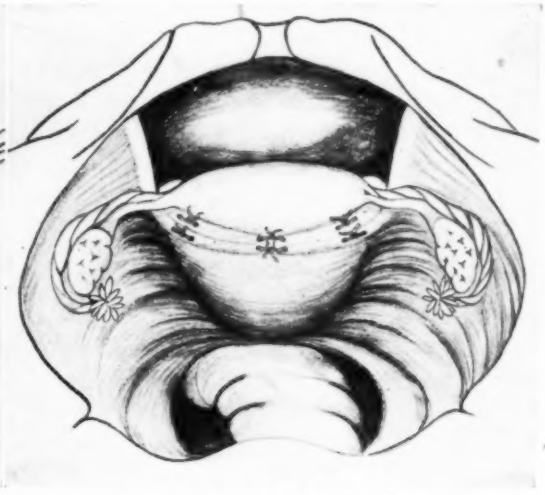

Fig. 6. Sutures in place.

of the uterus, thus forming a canal. Chromic catgut No. 2 is sutured through the loop of each round ligament and brought through the canal to the opposite side. Each round ligament is scarified. Traction is made on the catguts, pulling the round ligaments together in the center of the canal where they are sutured together with chromic catgut No. 2. The traction sutures are removed. Another suture is taken through each ligament on both sides just medial to the broad ligaments. The openings into the peritoneum are closed. (See Figs. 1, 2 and 3.)

When there is a large pelvis a second type of operation may be performed. Of both types the operation already described is the one of choice and the one we preform more often.

Operation No. 2. A curved Kelly forceps is pushed through the anterior layer of the broad ligament, then medial in the posterior wall of the uterus between the serous and muscular layer to the midline. This is repeated on the opposite side, thus forming a canal. The round ligaments are pushed into the canal with mosquito forceps. The ligaments are sutured in place. (See Figs. 4, 5 and 6.)

Third Step. The uterosacral ligaments are brought together posterior to the cervix. The ends are scarified and united with two sutures of chromic catgut No. 2. The ligaments and peritoneum where they now touch are scarified and a suture is taken in the midline and just lateral to the midline.

The first and third steps are done when abnormal conditions exist. The part of attachment in the canal should be sufficiently high to prevent the fundus from doubling backward over the loop and causing a retroflexion of the uterus. The opening in the broad ligament should not constrict the round ligament. The ligaments are sutured taut to offset any stretching that may take place. The muscular (upper) end of the round ligament has the tendency to stretch and break more than the fibrous connection tissue (lower) end; therefore this is taken care of by its use in the canal. All sutures are parallel with the ligaments, thus preventing interference with the blood supply. Each suture goes through the serous layer, ligaments and muscular layer.

ADVANTAGES

This method of operation has the following advantages:

1. It elevates the uterus and holds the fundus anterior.
2. It elevates the ovaries and fallopian tubes.
3. It keeps the uterus in the anterior position by a forward and downward pull of the round ligaments, the resistance of the encircling loop, and the intra-abdominal pressure which is exerted upon its posterior surface.
4. The uterosacral ligaments assist in position by keeping the cervix back.
5. It is noted for its simplicity and ease of performance.
6. There is no chance for adhesions and obstruction.
7. No recurrences have been observed to date.
8. It does not favor postoperative hernia.
9. It does not interfere with pregnancy.

This operation has been used in a large number of cases within the last three years with no recurrences of malposition up to the present time.

SUMMARY

1. There are objections to every kind of operation for uterine malposition at present.
2. Heretofore the term suspension operation has been incorrectly used. It should be reconstruction and correction operation. This is proved when we consider the anatomy and cause of uterine malposition.
3. In doing the first and third step of the operation when certain abnormal conditions exist, are great factors in the success of the second step or Sacher method of operation.
4. The method of operation which I have described overcomes all of the disadvantages and fulfils the cardinal requirements for uterine displacements.

PARESIS & OBSTRUCTION OF JEJUNUM

SECONDARY TO HYSTERECTOMY*

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THE case I wish to report is a patient with paresis and obstruction of the upper 3½ feet of jejunum secondary to a subtotal hysterectomy.

The patient is a female, single, fifty years of age, a public school teacher with a history of feeling a tumor mass in the right lower abdomen for the past fifteen months. The menses are regular. No menorrhagia or metrorrhagia. No vaginal discharge. Normal weight 109 lb. Present weight 105 lb. Pelvic examination reveals a hard, smooth tumor mass the size of a fetal head, filling the entire pelvis and another mass the size of a grapefruit arising from the upper right side of the pelvic mass. A diagnosis of multiple uterine fibroids was made.

A general examination of the head, neck, heart, and lungs was negative. Systolic blood pressure was 110, diastolic 70. Temperature 98.6°F. Pulse 80. Respiration 20. Blood count: R.B.C. 4,960,000, leucocytes 6800, hemoglobin 85, polymorphonuclear cells 60 per cent, lymphocytes 39 per cent, basophiles 1 per cent, coagulation time four minutes. Urine analysis: Sp. gr. 1.020, reaction acid, straw color and cloudy, trace of albumin, leucocytes 5–8 per high power field, erythrocytes fairly numerous, bacteria many.

On June 25 under ether anesthesia a subtotal hysterectomy was performed. The patient was in good condition, pulse between 70 and 90 and temperature not above 101°F. for the first forty-eight hours. On the second postoperative morning there was some distention of the abdomen and that afternoon she vomited once some dark green liquid.

One thousand cubic centimeters of normal saline with 5 per cent glucose twice a day, saline by rectum and nothing by mouth except sips of warm water were the standing orders from day of operation.

A soap suds enema on the second postoperative day brought a great deal of gas but the upper abdomen remained somewhat distended.

Lavage of the stomach brought 75 c.c. of greenish liquid.

Heat to the abdomen was ordered to stimulate peristalsis.

The third postoperative day at 4 P.M. the temperature was 99.4°F., pulse 70, respiration 20. The abdomen was distended, tympanitic, soft on pressure and there was no tenderness. Gas was expelled voluntarily and with soap suds enemas but the abdomen remainded distended and there was nausea and occasional vomiting of a dark green liquid.

A diagnosis of adynamic ileus was made.

The fourth day the same symptoms were present only increased in severity with the addition of colicy pains over the entire abdomen. The abdomen was now distended like a nine months' pregnancy. A soap suds enema brought a lot of gas but reduced the distention very little. Lavage of the stomach twice that day brought up about one pint of brownish liquid that had a sour odor. After lavage of the stomach 2 oz. of castor oil were inserted and returned with the next lavage seven hours later. A soap suds enema did not bring any sign of the oil.

A diagnosis of high intestinal obstruction was made and immediate operation advised. No flat *x*-ray plates were made because the colicy pains were so marked that there was no question of obstruction.

At 8:30 P.M. of the fourth postoperative day the abdomen was opened through the previous incision which was enlarged 2 inches for a better view of the upper abdomen.

A dark red mottled and markedly distended bowel protruded into the incision. This was found to be a distention of the upper 3½ feet of the jejunum and duodenum, produced by a sharp angulation of the bowel and held in place by adhesions for 4 inches along the lateral surface of the distended and collapsed bowel. These adhesions separated without cutting when the distended bowel was elevated.

* Read before Los Angeles Surgical Society October 9, 1931.

The collapsed bowel for about 2 feet distal to the distended jejunum appeared puckered as if in a spastic state. A moderate amount, probably one-half pint, of serum was free in the peritoneal cavity. No flakes or plastic lymph or other evidence of a general peritonitis was seen. The site of operation was clean and no bowel adherent to it.

At a point about 8 inches above the site of obstruction the bowel was incised, a male catheter inserted, the suction apparatus applied and about one quart of light brown thin, watery feces with a great deal of gas removed. Release of tension within the obstructed jejunum caused it to resume its normal color.

The opening was closed with No. 1 chromic catgut and covered with interrupted sutures of linen.

Because the obstruction was so high and the adhesions so delicate we believed it unnecessary to produce a permanent enterostomy or do more to the area formerly adherent. The abdomen was closed without drainage. The next morning the patient complained of crampy pains over the abdomen and had several bowel movements of a light brown color through the rectal tube. There was no distention of the abdomen.

The second day the patient had a yellowish liquid movement with a great deal of mucus. There were occasional crampy pains over the abdomen and she vomited a small amount of greenish liquid. There was no apparent distention of the abdomen.

The third day there was slight nausea and a little distention after a soap suds enema. Lavage of the stomach evacuated a little greenish liquid.

The fourth day the patient was still nauseated. Lavage of the stomach brought about one pint of brownish liquid. The abdomen was more distended. An ampule of surgical pituitrin was given hypodermically. Within about ten minutes she passed a large amount of brownish liquid feces and gas. Most of the distention disappeared but some was still present in the upper abdomen.

A liquid diet, 2 oz. every hour was ordered, in the belief that the sight and taste of food might promote normal peristalsis. Later some milk curds were detected in the stools so apparently something was going through.

Following this up to twenty-three days after the operation for obstruction the patient remained about in this same condition. About one-third of liquids and soft food ingested was taken care of but the remainder was either vomited or washed out of the stomach. From one-half to a pint of yellow or greenish liquid with a sour odor was washed out of the stomach twice a day and the abdomen remained distended like a nine months' pregnancy.

There were no colicky pains and no tenderness over the abdomen. The leucocyte count taken twice during this period was 7100 and 7550 respectively.

A low grade infection with a small Gram negative bacillus occurred in the subcutaneous fat of the wound but this cleared up in a few days and no evidence of peritonitis was seen. The general condition of the patient remained very good as she received 2000 c.c. of normal saline with 5 per cent glucose intravenously or subcutaneously twice a day in addition to the liquids and food she was eating. Nineteen days after the operation for obstruction the blood chemistry showed urea nitrogen 13.2 mg. per 100 c.c. (normal 10–15) and 220 mg. of sodium chloride per 100 c.c. (normal 400–500).

In view of the fact that but slight improvement had occurred after twenty-three days, and with the constant danger of loss of gastric and pancreatic secretion, operation was again advised. This was refused and in spite of consultation with four surgeons during her illness she decided to leave the hospital under the care of another physician. The attending surgeon told me that the condition cleared up entirely without operation in about ten days.

Most of us have had patients with adynamic ileus, obstructive ileus or a combination of the two because one may go into the other. The question we all ask ourselves is what has happened to the unobstructed bowel that is temporarily paralyzed?

Probably the most reasonable cause of adynamic ileus is an over-stimulation of the inhibitory nerves (splanchnics) of the intestines. The irritability of the bowel increases from the duodenum to the ileum, therefore a stimulus of the lower ileum requires a greater stimulus from the duodenum to overcome it.

Normal motion in the bowel is caudad and occurs in the presence or absence of

general peritonitis with direct stimulation, after both vagi and splanchnic nerves are severed. Back pressure is the only force which can prevent the bowel contents from passing toward the ileocecal valve. Stimulation of the lower ileum may create this back pressure.

Wagner in 1922 suggested that lumbar anesthesia might be used to diagnose adynamic ileus from obstructive ileus. Duval in a series of cases found this procedure unreliable. In 16 per cent of mechanical ileus cases an evacuation of the obstructed intestines also occurred.

The principal cause of death which follows high intestinal obstruction is due to chemical changes in the body fluids from loss of gastrointestinal secretions by vomiting and secondarily from circulatory and renal insufficiency.

The blood changes are decrease in the chlorides and a rise in the carbon-dioxide combining power to the plasma (alkalosis). The loss of the chlorides occurs in the vomitus. Dehydration by vomiting occurs only in high intestinal obstruction. Loss of pancreatic juice produces death by dehydration and acidosis. Partial loss of both gastric and pancreatic secretions may be followed by alkalosis or acidosis, mild or severe depending upon the case. Total loss of bile is compatible with life for a long period and produces no marked blood changes.

TREATMENT

The principal treatment for adynamic ileus is: Remove the nervous inhibition by injecting the splanchnics directly with a local anesthetic or indirectly by a spinal anesthetic. The use of choline, atropine and pituitrin is recommended. Intravenous injection of hypertonic saline solution, 3000 c.c. of 3 per cent solution to 50 c.c. of a 25 per cent solution. Food, especially meat and water, stimulates normal peristalsis and is advisable even if returned by vomiting. An enterostomy is often the only safe surgical means of overcoming obstructive ileus but if the obstruction is very high the rapid loss of gastric and pancreatic secretion through the tube may not avert death. In such a case it probably would be well to make a second enterostomy and inject the secretions from the vomitus and upper tube into the lower enterostomy. In all cases sufficient water and saline must be supplied to overcome the rapid dehydration and loss of chlorides.

LEFT FRONTAL LOBE ABSCESS

FOLLOWING DEPRESSED SKULL FRACTURE*

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LOS ANGELES, CALIF.

THE following case represents an example of a compound comminuted depressed left frontal fracture with secondary frontal lobe abscess formation, with recovery.

J. F., aged twenty-four, single, white, male, No. 168,303, was admitted to the Los Angeles General Hospital on July 14, 1931, in a semicomatose condition. A history was obtained that he was in an automobile accident on April 19, at which time he sustained a skull fracture in the left frontal region which was compound and comminuted. He was supposed to have lost considerable brain tissue through the wound. The patient was unconscious for a period of ten hours; was semiconscious for seven days. Ten days after his injury he had an operation for wound repair. He was discharged from the hospital on May 6 (seventeen days after the accident). Several days later he had a vomiting spell and became stuporous, complaining meanwhile of a headache. The region of the left forehead had become swollen and had a greenish aspect. He was taken back to the hospital where the wound was reopened and some necrotic tissue removed. This seemed to relieve the headache and the patient returned to work.

After working about two weeks, he had one spell of headache, associated with vomiting. On the night of July 3, he complained of not feeling well and vomited. He fainted shortly after and was put to bed. The following day he felt some better but was inclined to be very drowsy. The next day he felt irritable and refused to eat. A change in character was noted at this time. He became loud and boisterous, had spells of amnesia and became very profane. This was extremely contrary to his nature. His talk was stated "to have no sense to it." On a few occasions he would drive up to his work, stop the car and doze off to sleep. On awakening he would drive on to his other duties, not realizing that he had done no work. He continued in this condition until July 7, at which time he was ordered back to the hospital by his physician; from there he was referred to the Los Angeles General Hospital on July 14.

Examination on admittance revealed a young adult somewhat stuporous and apathetic. There was a healed scar in the left frontal area. It was thought that a bony defect could be palpated underneath this scar. The pupils reacted to light and accommodation; the right pupil being larger than the left. There was a double choked disc of three to four diopters' elevation. All deep reflexes were increased on the right and a right ankle clonus and Babinski reaction were elicited. A slight right hemiparesis was noted. Impression was that of possible left frontal lobe abscess, secondary to depressed fracture.

X-ray examination revealed a much comminuted fracture with marked depression in the left frontal area of the skull. Laboratory findings were as follows: White blood count 6800; red blood count 4,600,000; polymorphonuclears 75 per cent. Spinal puncture revealed a clear colorless fluid under increased pressure of 400 mm. (water) pressure. There were 20 cells per c.mm. No globulin was present. Urinalysis was entirely negative. The patient's temperature during this time ranged between 98° and 101°F.

Under general anesthesia, an operation was performed on July 20, 1931. A T-shaped flap was turned down revealing a depressed area of bone. Six fragments were removed which were embedded in granulation tissue and cortex. The dura was then opened and a ventricle needle was inserted to a depth of 3.5 cm. At this level a firm resistance was encountered. Puncturing this resistance revealed pus. The needle was withdrawn and a No. 20 catheter was inserted and sewed to the dura, fascia and skin. Usual closure of the flap was made.

The wound drained profusely for about a week postoperatively, and then drainage

* Read before the Los Angeles Surgical Society, October 9, 1931.

ceased. On July 30, the wound was reopened and the tube removed. The abscess cavity was again located with a ventricle needle and the drain replaced. The patient from that time on made an uneventful recovery. The drainage being profuse for the first week. The temperature soon became normal, pulse regular, ranging from 60 to 90. He had no headaches and felt perfectly well. The tube came out of its own accord on August 25. The patient remained symptomless and the wound has ceased drainage.

Eyeground examination showed a markedly subsiding pressure and normal limitations approaching.

Patient was discharged on September 9, 1931.

This case clearly demonstrates the value of *x*-ray examination following injury to the head, before surgical procedures are instituted. It is our policy to elevate all cases of depressed comminuted skull fractures as the fragments are potential sources for brain abscess, as well as other late sequelae. It is also well in this type of case to count the number of fragments revealed in *x*-ray with the number of fragments recovered at time of operation. In this way one is more certain that no remaining fragments are left. If very small, the fragments may be irrigated out with saline solution, by means of a rubber catheter. When the abscess has a firm capsule and is well loculated, prognosis for recovery has been about 50 per cent.

It should always be remembered that when these abscesses are first drained, one should not become alarmed at the absence of drainage material. The abscess has emptied itself; the walls have collapsed, and profuse drainage does not ordinarily ensue until about the third or fourth day. It has always seemed a great temptation to pull or adjust the drainage tubes. It is our policy not to disturb them unless definite indications arise. Dressings are applied daily in these cases and great care is exercised with them.

BLOOD VESSEL LIGATION TECHNIQUE*

the volar aspect of the thumb and is grasped by the adjoining index finger, thus pushing the short end down through the loop. (Fig. 10.)

3. The knot is completed by grasping the short end between right thumb and index finger and both ends are pulled tight, using the left index finger as a directing force to make sure the knot is tight. (Figs. 11 and 12.)

In my experience in teaching students the technique of tying the "granny" and "square knot," I found that the greatest confusion takes place in the steps illustrated, especially in Figures 2 and 8 respectively. It is therefore hoped that the foregoing description and illustrations will help those interested in using these knots in ligating vessels.

*Continued from p. 123.

POSTOPERATIVE HERNIA*

A CONSIDERATION OF ETIOLOGICAL FACTORS

R. W. McNEALY, M.D., F.A.C.S., AND MANUEL E. LICHTENSTEIN, M.D.

CHICAGO

IN a review of one's surgical experience, one is often struck by the fact that the occurrence of a postoperative ventral hernia creates a pathological condition which in many instances is more formidable than the pathology for which the primary operation was performed. We have interested ourselves in the experimental production of postoperative hernias in laboratory animals hoping by this study to obtain information that would be of assistance in evaluating the factors responsible for the occurrence of postoperative herniations in clinical work. A correlation of these experimental data with our clinical experience has led us to believe that the most important factors in the production of these hernias may be grouped under the following heads: (1) excessive tension, (2) malocclusion, (3) perforations, (4) infection, (5) muscle paralysis, (6) systemic disease.

FIG. 1. Transversus muscle beneath posterior sheath of rectus muscle.

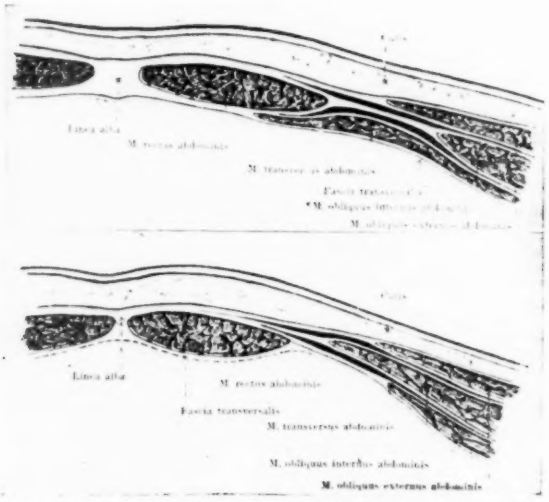

FIG. 2. Sections of abdominal wall illustrating position of transversalis fascia and transversus muscle.

EXCESSIVE TENSION

Increased intra-abdominal pressure of an intermittent type such as is caused by coughing, vomiting or straining in defecation or urination is likely to result in loosening or tearing-out of stitches or the forcing of omentum or fat between the approximated layers. The continuous presence of increased intra-abdominal pressure such as occurs in paralytic ileus or incomplete obstruction may also tend to produce the same accidents as occur in the intermittent form and in addition such prolonged distention renders the parietes ischemic and this ischemia markedly delays the healing process.

In some instances, excessive tension results from an attempt to bridge too wide a defect with insufficient tissue. There follows a tearing-out of the stitches or the thinning-out of the scar during the process of healing until a weakened area is produced. It has been shown that a simple incision in fascia will be followed by perfect healing provided no undue tension is present. If, however, the incision be sub-

* From the Department of Experimental Surgery, Northwestern University Medical School, Chicago.
Submitted for publication October 14, 1931.

jected to excessive tension, the defect will be bridged with loose areolar tissue similar to that which covers fascia elsewhere.

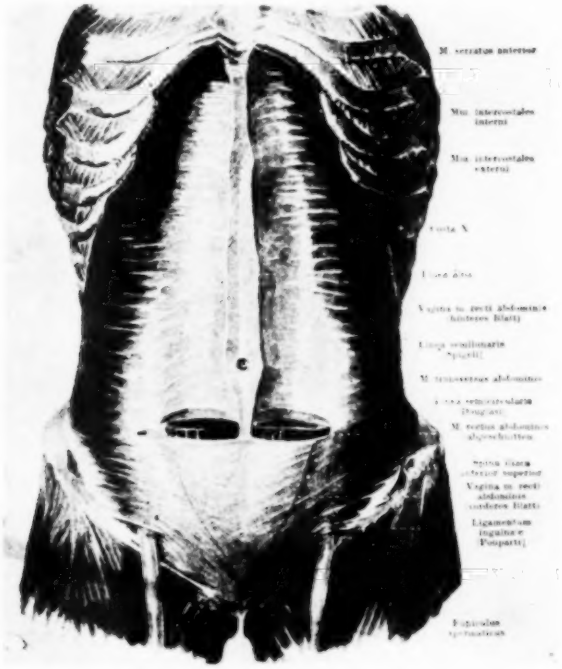

Fig. 3. Transversus muscle.

This areolar tissue will, of course, not offer the same support as normal fibrous tissue.

MALOCCLUSION

Experimentally, it has been shown that like structures will unite most readily and most firmly with like structures, that is, fibrous tissue will heal to fibrous tissue, skin to skin and bone to bone. A capital illustration of this is offered in the usual repair of an indirect hernia in which the conjoined tendon (falx aponeurotica inguinalis) is sutured to Poupart's ligament (ligamentum inguinale). It has been believed that a firm union takes place between these structures but observations on cadavers having herniotomy scars as well as herniotomies requiring re-operation have shown that only a flimsy union occurs and separation of the previously approximated structures takes place. Experimentally, on dogs we have been able to confirm the previous work of Seelig and Chouke, who showed that when the internal oblique muscle is sutured to Poupart's ligament as is usually done in a hernial repair, separation occurs soon afterward. The reason for

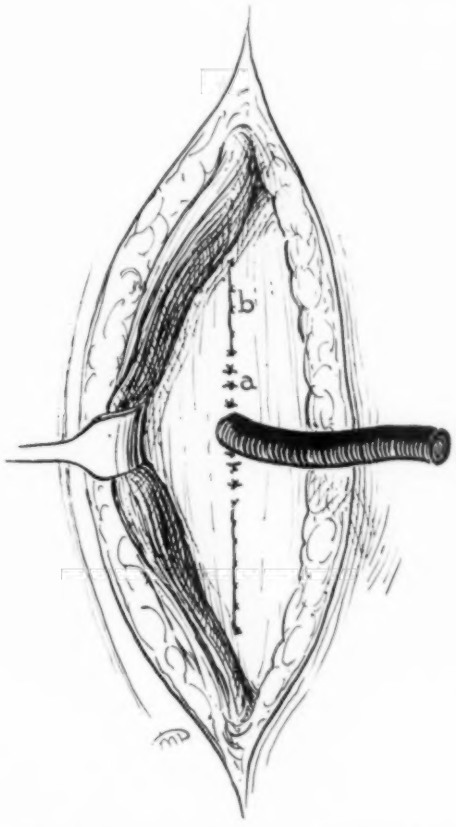

Fig. 4. Use of interrupted sutures above and below a drain.

this is not far to seek. In this procedure, we have the approximation of parallel bands of muscle tissue to parallel fibers of fibrous tissue. The smooth connective tissue investments of the muscle and Poupart's ligament act as a barrier to their common union.

This fact has been taken advantage of by Koontz and others who found it advisable to cut off the edge of the internal oblique muscle and completely remove the smooth covering of areolar tissue that lies upon Poupart's ligament. The approximation of raw surfaces permits a firm union to occur between the muscle and the fibrous ligament. Microscopic examination of sections taken from such united structures shows that the union occurs between the fibrous elements of the muscle, the epimy-

sium, perimysium and endomysium; the muscle tissue itself taking no part in this union.

Fig. 5.
Figs. 5 and 6. Dog. No. 10.

Another elementary fact made note of in the preceding is the removal of the loose areolar tissue that lies upon Poupart's ligament. It has been shown that this loose areolar tissue is a barrier to healing of approximated structures. The reflection of a segment of fascia lata upon itself without the removal of the overlying areolar tissue will not result in firm union of the overlapped surfaces. Complete removal of this areolar tissue with scarification of the opposed surfaces will result in a firm union.

The approximation of the principal fascial planes of the abdominal wall is the first consideration in the avoidance of postoperative ventral hernias. Probably the most important fascial plane of the abdominal wall, judged from this viewpoint, is the transversalis fascia. This layer is of such great importance in our opinion that it would be worth while at this time to review the anatomical relations of this layer.

Our observations on dogs, human surgical material and cadavers have shown that the transversalis fascia is a definite and distinct layer that is easily found and separated in the lower abdomen. It is a fairly thick layer bounded internally by the properitoneal fat and peritoneum and externally by the transversus muscle and

Fig. 6.

fascia. As one follows this fascia cephalad, it appears to thin out and finally fuse with the aponeurotic fascia of the transversus muscle. In the upper abdomen toward the midline the transversus muscle and fascia make up in thickness for the diminished thickness and strength of the transversalis fascia. (Fig. 1.)

The transversalis fascia invests the entire abdomen, being continuous with the fascia on the under surface of the diaphragm, the iliac fascia and the lumbar fascia. It is this continuous layer that tends to equalize the intra-abdominal pressure. When a defect arises in this layer any increase in intra-abdominal tension will tend to increase the defect.

In the upper abdomen the transversalis fascia does not appear as a distinct layer since it is fused with the aponeurotic extension of the transversus muscle. The illustration shows that the transversus muscle behind the posterior sheath of the rectus muscle amply supplements the

thinned-out transversalis fascia. In any wound closure, the importance of accurate approximation of these tissues cannot be overemphasized. (Figs. 2 and 3.)

Operative work on the right upper quadrant affords considerable opportunity for the development of postoperative herniation. In many instances, there is a failure to accurately close the transversus muscle and posterior sheath of the rectus muscle. In emaciated individuals all of these structures may well be included in the grasp of one suture. However, in the more muscular or obese individuals, these layers may require at least two layers of suturing to secure approximation of like structures.

In the lower quadrant of the abdomen where the transversalis fascia is usually separated from the peritoneum by a layer of properitoneal fat, it is important in the closure of the wound to approximate the incised edges of the fascia and peritoneum on one side to the like structures on the opposite side. In many instances, retraction of the fascia of one side of the wound often results in a suture of the fascia of the opposite side to a fatty layer. Such suturing results in defective healing. In view of the importance of the approximation of like structures, more attention should be paid to the identification of each layer of the abdominal wall.

PERFORATION

When a drain is permitted to remain in a wound for a prolonged time, healing of the adjacent fascial layers will occur except for the portion held open by the drain. Through this defect a tag of omentum or fat may be drawn on removal of the drain or may find its way into the opening as a result of increased intra-abdominal pressure. Experimentally, it has been shown that the protrusion of a portion of omentum or fat through the transversalis fascia may be the nucleus for the gradual development of a postoperative hernia. In this connection, it may be stated that the increase in size of protruded hernial contents is not only due to the continuous extrusion of omentum and occasionally loops of bowel, but also to the actual growth of the already extruded omental fat.

The avoidance of the prolonged use of drainage material would, of course, diminish the possibility of postoperative herniation in a definite number of cases. In passing, it may be stated that the inadvertant suturing of a drain into a wound with the same suture that is used to close the transversalis fascia and peritoneum may be the basis for a postoperative hernia. Usually, when such suture has occurred, the drain is loosened by removal of the suture. This may loosen the entire approximation of the important layer already noted. Along the tract of every drain there is more or less extension of infection from the surface toward the peritoneum or vice versa, resulting in a premature absorption of those sutures nearest the drain. If such sutures are a part of a continuous suture a serious separation may follow. To avoid this, it is suggested that several interrupted sutures be employed immediately above and below the segment through which any drain penetrates. (Fig. 4.)

Transfixation of a sac in a herniotomy may produce a slit through which a tag of omentum may protrude. Thus, a hernia may develop, the etiology of which is quite different from that of the original hernia. This is especially so in thin-walled, recently developed sacs of the inguinal variety.

INFECTION

Infection plays a definite role in the development of postoperative ventral herniation. Here the cause is not difficult to find since infection causes extensive sloughs of the fascial investments of the abdomen leaving little to maintain the integrity of the anterior abdominal wall. There are several important factors worth noting at this time, which may be of value in diminishing the number of postoperative hernias from this cause. It must be remembered

that of all of the tissues of the body, the most resistant to infection or the most capable of coping with infection is the peritoneum. Perhaps the least resistant tissues are fat and fascia. When infection is present in the peritoneal cavity good surgical judgment may sometimes dictate the use of drainage material down into the peritoneal cavity. This will tend to carry the infection to such structures as fascia and fat. In a recent paper, Garlock suggested that in suppurative appendicitis, where the McBurney incision is used, no attempt be made to suture the wounds, they being left wide open wherever possible. His comparison with similar cases which were sutured showed that the non-sutured cases were followed by less than half as many postoperative ventral hernias.

Fig. 7.
Figs. 7–9. Dog No. 15.

It is important in this instance to keep in mind that the opening in layers superficial to the peritoneum must be of such size and patency that there will be no confining of the discharge. The tendency to close fascia and skin snugly around drains leading into the peritoneal cavity is probably one of our commonest surgical errors.

MUSCLE PARALYSIS

This of itself may not be an important factor in the development of postoperative herniation but the role muscles play in serving as a splint to a wound by their reflex spasm may influence herniation. In the usual right rectus incision, the medial third of the rectus muscle is separated from its nerve supply, thus producing a weakness in this medial portion of the muscle. Unfortunately, at times as much as half or two-thirds of the muscle is deprived of its nerve supply, thus giving a greater abdominal weakness because of muscle paralysis.

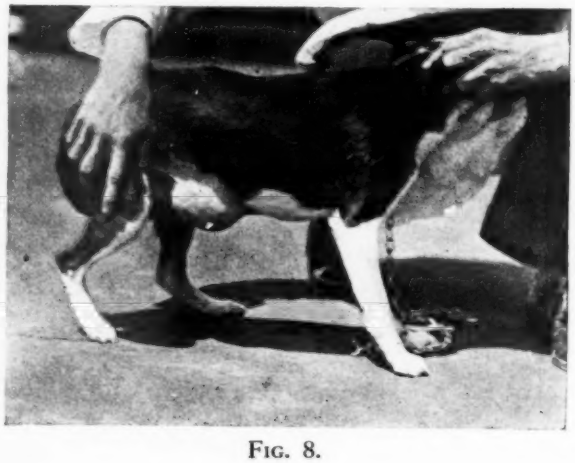

Fig. 8.

In local infiltration and block anesthesia muscle paralysis also occurs. As a result any undue coughing without the reflex contraction of the abdominal muscles tends to blow out the sutures along the incision, making possible the operation of factors 1 and 2 in the development of a postoperative hernia. This suggests the value of special care in the use of abdominal binders and adhesive strapping so as to supply to the abdominal cavity the necessary support unable to be given by the weakened abdominal wall. Too often, loose application of the adhesive or abdominal binders permits early separation of the approximated structures by the increase of intra-abdominal tension due to coughing or accumulation of gas in the bowels.

One, too, should remember that trauma due to continuous traction on a muscle as occurs when self-retaining retractors are

Fig. 9.

used, produces a temporary paralysis of the muscle. This renders the muscle so deficient in tone that it does not efficiently splint the incised wound in its posterior sheath.

SYSTEMIC CONDITIONS

Diabetes, syphilis, tuberculosis, carcinoma, etc. may interfere with healing sufficiently to prevent firm union of a postoperative wound, thereby favoring the occurrence of herniation.

EXPERIMENTAL CONSIDERATIONS

In our experimental work, we have been impressed with the difficulty of producing ventral hernias in dogs. In many instances, we have excised large segments of both recti muscles in addition to the external oblique and internal oblique muscles and failed to produce any herniation of the anterior abdominal wall. It was this fact which led us to believe that the integrity of the anterior abdominal wall was largely maintained by the intact transversalis fascia and transversus muscle.

Figures 5–9 illustrate hernias in dogs produced in the manner described in the abbreviated accounts of the experiments.

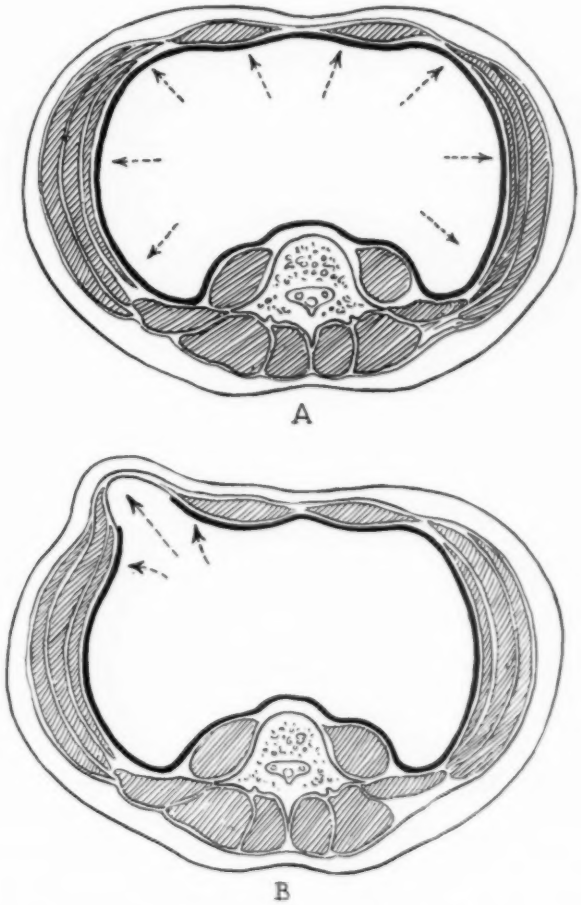

Fig. 10. Distribution of intra-abdominal forces.

Dog No. 10. Importance of an intact transversalis fascia. Figure 5 shows a large ventral hernia produced by removal of all layers of the anterior abdominal wall except the skin and peritoneum to the left of the midline. Figure 6 shows the anterior abdominal wall of this dog with skin dissected away from defects. To the right of the midline is a stellate scar representing a defect in the right rectus muscle. This scar is firm and maintains the smooth firm contour of the abdominal wall. To the left is the hernial sac bulging through the defect produced by the same procedure as employed on the right side with the additional removal of the posterior sheath of the rectus muscle and portions of the transversus muscle. A definite firm ring is present and the extent of the bulge can be appreciated from Figure 5. There was no

defect produced in the peritoneum which remained intact and through which could be seen the subjacent coils of intestines.

In several dogs operated upon in a similar manner, deaths occurred due to strangulation of loops of bowel which herniated through the opening in the transversalis fascia and transversus muscle.

Dog. No. 15. (Figs. 7 and 8). These photographs illustrate the extent and size of a ventral hernia that developed following the protrusion of portions of omentum through a poorly closed peritoneum. This corresponds to the opening left in peritoneal cavities by drains. In the production of this hernia, a portion of the rectus and external and internal oblique muscles was removed (this is not sufficient to produce a hernia). A linear incision was made through the transversus muscle, transversalis fascia and peritoneum. These layers were then sutured in such a manner that omental tags protruded.

Figure 9 shows the same dog reoperated upon three months later. A considerable quantity of omentum had protruded through the anterior abdominal wall defect. This was returned into the abdomen. A firm closure of the peritoneum was made and a fascial transplant was sutured into the defect of the anterior abdominal wall. This resulted in the cure of the hernia.

Dog No. 22. No herniation occurred in this animal following the removal of the anterior and posterior sheaths of the rectus muscle and transversus muscle, leaving the rectus muscle, itself, undisturbed. The defects produced measured 2½ inches in diameter but in two months a firm scar tissue had completely filled the defects produced. The intact rectus muscle was sufficient to maintain the integrity of the anterior abdominal wall.

DISCUSSION

While it is sometimes difficult to reconcile results produced in experimental animals with those in man, there are several points in common which clinical observation will confirm. An individual with a strong untraumatized rectus muscle which has not been denervated is less apt to develop a hernia than the individual whose rectus muscle is flabby, traumatized or denervated during the operative procedure.

In considering defects of the abdominal wall, one may well think of the transversalis fascia and peritoneum as the "inner tube" of the abdomen with the oblique muscles and recti as representing the outer "casing" (Fig. 10). A defect in the inner tube will produce a "bulge" (herniation) because of the unequal distribution of pressure in the abdominal cavity. Usually the immediate cause for the hernia acts soon after the operation is completed, thus allowing structures to insinuate between the incised edges of the parietes acting as an opening wedge which may, as time goes on, cause a gradual increase in size of the hernia.

CONCLUSIONS

From our clinical and experimental observations the following deductions may be made.

1. Postoperative herniations of the anterior abdominal wall are due to one or several of the following causes:

(a) Excessive tension on the suture line.

(b) Malocclusion of the incised layers of the abdominal wall.

(c) Perforation of the wall by fat or omental tags.

(d) Infection of the fascias with subsequent sloughing.

(e) Muscle injury or paralysis.

(f) Systemic conditions such as diabetes, tuberculosis, syphilis and occasionally localized carcinomatous infiltration.

2. The transversalis fascia and the transversus muscle play an important role in maintaining, when intact, the integrity of the anterior abdominal wall.

3. Accurate approximation of like structures is conducive to firm union.

4. The intelligent application of abdominal binders and adhesive tape to the abdomen following closure of an abdominal wound in a manner to relieve the tension on the suture line assists in securing firm union.

PRIMARY TUBERCULOSIS OF THE BREAST*

LOUIS E. MAHONEY, M.D., F.A.C.S.

LOS ANGELES, CALIF.

THIS patient was a Spanish-American woman, aged twenty, born in Texas, employed as a packer by a canning company in Los Angeles. She has one living child, born at the Los Angeles General Hospital, June 24, 1929 and now thriving normally. The husband died two years ago of pulmonary tuberculosis and the patient has had yearly examinations since then with no evidence ever discovered of tuberculous disease. She presented herself at the Out-Patient Department on July 31, complaining of a sinus in the upper outer quadrant of the right breast which had been in existence for over one year and frequently drained bloody and serous fluid. She stated that she had nursed her baby for five months and that during that period a hard, painless lump developed in the breast. This was opened and drained at the White Memorial Hospital in July, 1930. She states that the wound drained until May, 1931 at which time it closed, only to reopen again in the middle of July, 1931.

Physical examination disclosed a robust, healthy appearing, young woman about 5 feet 3 inches tall and weighing approximately 125 lb., and was essentially negative save for a small draining sinus at the breast margin in the upper outer quadrant. The sinus admitted a fine probe. Palpation revealed a small, hard, firm lump in the breast tissue and apparently attached to the muscle. Firm pressure on this lump caused severe pain which radiated over the right clavicle and down the right arm. When first seen some type of chronic infection or fungus was suspected and smears and cultures were made to rule out actinomycosis, coccidoidal granuloma, etc., and nothing but a few staphylococci were found in the smears or cultures. An *x*-ray of the chest was made to rule out osteomyelitis of a rib and nothing was found. It was then thought we were probably dealing with an infected cyst and cauterization with silver nitrate and other methods were attempted but with no favorable result. The patient was therefore admitted to the surgical ward on August 16, 1931, and operation done on August 17.

The operative procedure was started with a wide infiltration of 0.5 per cent novocaine. The sinus was then injected and to our surprise took more than 12 c.c. of methylene-blue solution. The injection produced very severe pain which radiated down the right arm. The operation was started under local anesthesia, but the patient soon complained rather bitterly and it was completed with gas oxygen. Upon opening the fistulous tract it was found to branch out in several directions through the upper right quadrant of the breast, and to involve the pectoralis major muscle. A small potion of the abscess wall was sent to the surgical pathologist and he reported the presence of giant cells suggestive of tuberculosis. The operation was then completed and every portion of diseased and scar tissue removed. When finished it would have been possible to thrust one's hand into the cavity. A rubber tissue drain was inserted and the wound healed up rather promptly. The pathologist's report on tissue removed was as follows:

"The specimen consists of several irregular tags of skin and subcutaneous tissue to which a small amount of muscle is attached. The specimen is stained with methylene-blue and is said to be tissue removed from a chronic sinus of the breast.

"*Rapid frozen section* reveals chronic inflammatory tissue containing giant cells. Diagnosed as probable tuberculous granulation tissue.

"*Microscopic:* Section showing tubercles and giant cells.

"*Diagnosis:* Tuberculous granulation tissue."

The patient reported at the Out-Patient Department on September 5, with the wound entirely healed and no discharge.

I have taken occasion to review the records of the General Hospital for the past five years and find that 597 patients

* Read before the Los Angeles Surgical Society, October 9, 1931.

were admitted to the hospital wards with some disease of the breast. Of these admissions, 171 were listed as mastitis, 35 as puerperal and 31 as abscess non-puerperal, a total of 237 in all listed as inflammatory. The balance of 360 cases were new growths of which 321 were carcinomatous. In passing it is interesting to note that only one sarcoma of the breast has been observed in five years time and in almost 600 cases. Unfortunately the record system which is otherwise very complete does not list a heading of tuberculosis of the breast, and I am unable to state how many, if any, of these cases should fall in that classification.

Tuberculosis of the breast is a rather rare disease. Deaver reviewed the literature in 1914 and could find only 90 proved cases from 1881 to that date. Since then an average of 2 to 4 have been reported yearly, so there are probably not many more than 150 definitely proved cases in the literature thus far.

The disease can be either primary in the breast or secondary and arising from some other previously existing focus. About 3 out of 5 instances are primary in origin. A typical history would be about as follows: A woman, otherwise healthy, between the ages of twenty and thirty discovers she has a small, slightly painful lump in her breast. This goes on for several months, at the end of which time it breaks down, discharges some caseous material and a persistent sinus forms. If surgery is done at this time and the diseased area entirely eridicated, cure is certain.

The average duration of this disease is about ten months. The treatment is surgery, and the infected tissue should be removed in toto. Some form of inhalation anesthesia should be employed. Following operation the wound almost invariably heals by first intention and the patient experiences no further difficulty. The condition may be, and sometimes is confused with new growths, or with carcinomata. Both tuberculosis and carcinoma can be present in the same breast, but the possibility is so rare that it may be ignored.

TETANUS FOLLOWING ACUTE APPENDICITIS*

understood, but the present-day treatment leaves much to be desired.

It has been suggested that all operative cases involving the appendix and colon be given a prophylactic dose of antitetanus serum. This seems impractical as there would probably be a higher mortality from serum reactions than from the infrequent case of tetanus.

The fact that tetanus bacilli normally inhabit the colon of many individuals is one argument for treating and inverting the appendix stump following appendectomy.

In the treatment of this case the intravenous use of sodium amytal seemed of definite benefit in controlling convulsions.

Some surgeons believe the intraspinal use of the serum to be harmful. The fact that in this case a fatal convulsion occurred ten minutes after an intraspinal injection might tend to favor this theory.

* Continued from p. 99.

TETANUS FOLLOWING ACUTE APPENDICITIS*

WILLIAM P. KROGER, M.D., F.A.C.S.

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THE advent of tetanus in the postoperative course of an appendix operation is perhaps the most tragic and startling complication with which the surgeon has to deal. Fortunately such an infection is extremely rare, so rare in fact that many surgeons of wide experience have never observed a case.

Six years ago Wainwright collected only 37 cases from the American and British literature, covering a period of twenty years, and since then I have only found 2 additional cases.

Tetanus may occur after any operation, but its occurrence is more likely following operations in which the intestinal tract has been opened, such as appendectomies. This is because the tetanus bacillus normally inhabits the colon of many individuals.

The following case was recently observed at St. Vincent Hospital:

CASE 1. Mr. J. A. S. aged thirty-six, was admitted to the hospital on August 8, 1931. A diagnosis of acute appendicitis was established and an immediate operation advised. At operation considerable free fluid was found in the peritoneal cavity. The cecum and ascending colon were congested and indurated. The appendix was retrocecal and gangrenous throughout. An appendectomy was done; the stump ligated and treated with iodine, but it could not be inverted because of the thick indurated cecum. A Penrose drain was inserted and the wound closed. No cultures or smears were made of the peritoneal fluid.

The pathologic examination of the specimen showed acute gangrenous appendicitis, with a fecolith in the mid portion.

Following the operation the patient developed a diffuse peritonitis and for about eight days his progress was very stormy. Considerable pus drained from the wound and on the tenth day the sloughing fascia allowed the wound to separate. The margins were partially retained by adhesive straps. Gradually the convalescence became smoother but on the morning of the nineteenth day the patient complained of stiffness of his masseter muscles and spasmodic contractures of his abdominal wall. A diagnosis of tetanus was promptly made and treatment started. Two minums of antitetanus serum were given intradermally to test for a possible serum reaction. After thirty minutes no reaction was observed so 20,000 units of the serum were given intravenously and 20,000 units intraspinally. A large dose of sodium amytal (1200 mg.) intravenously effectively controlled the convulsions. Large doses of the serum were given about every four hours; into the veins, the spinal canal, and the muscles; until a total of 120,000 units had been given. For twenty-four hours the patient rested easily and seemed to improve; then convulsions occurred in spite of sodium amytal, magnesium sulphate, and morphine.

Forty hours after the onset of symptoms, 20,000 units of antitetanus serum were given intraspinally. Ten minutes later the patient developed a severe convulsion and expired from respiratory spastic paralysis.

Cultures made from the wound were examined and the material injected into guinea pigs, but no tetanus bacilli could be demonstrated.

Autopsy: The main features of a complete autopsy showed a local peritonitis in the lower right abdomen and a sinus leading from the mesentery of the terminal ileum to the incision.

In the spinal cord there was chromatolysis and actual necrosis evident among the nerve cells of the anterior horn cells. The vessels of the medulla were engorged with blood, in many cases these appeared to be red agglutinated thrombi. The brain tissue showed evidence of early softening in a number of areas.

COMMENT

The bacteriology, pathology, and prophylaxis of tetanus is apparently well

[Concluded on p. 98.]

* Read before the Los Angeles Surgical Society, October 9, 1931.

DO SYMPATHETIC NERVES TRANSMIT PAINFUL IMPULSES?*

REPORT OF CASE

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THAT sensory impulses may be carried by the sympathetic nervous system is a conception that is far from proved; however, here is a gradual accumulation of clinical observations which lend support to this idea. Many of these observations have been made on patients who have had somatic nerve pathways of a part interrupted in an attempt to relieve them of pain. With failure to relieve pain by division of the somatic nerves the sympathetic trunks of the part have been interrupted by ganglion extirpation or alcoholic injection with variable results. Other observers have reported the changes following destruction of the sympathetic pathways alone, but since most of this was done by alcoholic injection, the conclusions could be questioned. It is the purpose of this report to record an instance of residual pain in the neck following operative interruption of the somatic nerve pathways of the part.

FIG. 1. Outlined area was completely anesthetic to touch, pinprick, and all degrees of heat and cold. Deep sensibility was absent over left side of neck but present over face and musculature of left shoulder girdle.

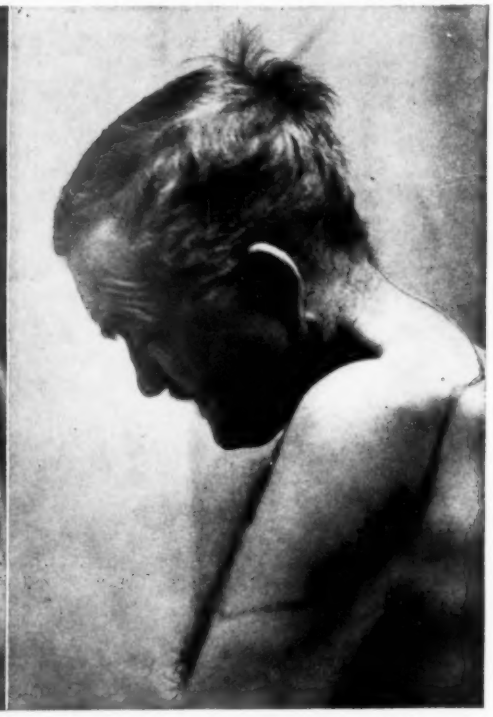

FIG. 2. Extent of cutaneous insensibility over upper back and shoulder areas following division of left first, second and third cervical nerves with dorsal roots of fourth cervical segment.

L. I. C. H. No. 30-6589. J. N. aged fifty-eight, a gardener, was admitted on August 14, 1930 to the surgical service, complaining of severe pain in the left side of the face and left lower jaw. The past history was entirely

* Submitted for publication November 4, 1931.

negative except for periodic alcoholic sprees and excessive use of tobacco.

In the early part of 1929 he noticed a small ulcer on the left half of the lower lip which failed to respond to local treatment. In the late spring of the same year he consulted a surgeon who excised the ulcerated area by removing a wedge-shaped piece of the lip. (Section of this tissue showed squamous cell carcinoma.) The wound healed well but during the summer there was a recurrence very similar to the original ulcer. Shortly thereafter he felt several hard, painless lumps beneath the left ramus of the mandible. In September 1929 he was advised to enter the Memorial Hospital of New York for treatment. At this institution the left submaxillary group of lymph glands were removed and radium applied to both the lip and left upper neck area. The growth on the lip completely disappeared. The patient continued with radium treatments throughout October and November 1929, improving all the while in general health. In the early summer of 1930 there was first noticed a dull aching pain beneath the left ramus of the mandible associated with an occasional sharp pain radiating upward over the posterior aspect of the head. Further radium and *x*-ray therapy were of no avail; in fact the pain was made worse by these treatments. Finally after failure of narcotics to relieve the pain which was daily increasing in severity, it was decided to attempt operative relief.

Upon admission examination showed a well-developed but slightly undernourished male of fifty-eight, sitting in bed with head drawn downward and to the left. The left half of the face was moderately swollen, reddish in color and quite firm. Saliva was drooling continuously from the left angle of the mouth which was drawn downward by a firm scar at the site of the original growth. The tongue was swollen and could not be protruded due to its firm attachment by what seemed to be a dense scar in the floor of the mouth. About the operative scar of the neck there was a zone of tissue, not raised, which was of cartilaginous consistency. At the most posterior area of this scar there was a raised area approximately 2 cm. in diameter, bluish domed, very firm and painless to pressure. In fact this entire area was not tender. The patient described his pain as a severe ache in the region of the neck scar with frequent stabbing pain radiating upward both anterior and posterior to the left ear. The remainder of the physical examination was unimportant.

Because of the location of the pain it was thought rational and advisable to divide the upper cervical nerves on the left side, so on August 18, 1930 under ether anesthesia an intradural division of the left first, second and third nerves, and the dorsal roots of the fourth cervical nerve was performed. Following the immediate operative pain he was quite comfortable for one week. At this time he began to complain of a dull ache over the entire left frontal area of his head and occasional sharp pains in the gum of the left mandible. This discomfort increased in severity, becoming agonizing in intensity so that it was decided to divide both roots of the left fifth cranial nerve.

Second operation: On September 8, 1930 under local anesthesia the roots of the left fifth cranial nerve were divided. For two weeks following the second operation he was almost completely relieved of pain. At the end of this period, however, he began to complain of a dull pain in the left side of the neck and temporal region of the head. He described the pain as different from his previous discomfort, likening it to a cramp which increased in severity during any activity such as walking. Examination at this time showed complete cutaneous anesthesia of the entire left side of the head, left half of the neck and left shoulder, yet the patient's discomfort at the end of the two surgical procedures was as great if not greater than at the beginning. Therefore narcotics were again resorted to with partial relief until after six weeks of medicinal confusion the patient died, November 7, 1930.

DISCUSSION

Several observers have advocated the transmission of painful impulses through the sympathetic nervous system, notably Mixter and White, Foerster, Grant, and Fay. The variability of the operative methods used in the reported cases and the inconstancy of the results obtained has left many in doubt. In many instances the nature of the lesion and its exact location was unknown although there was

every justification to attempt operative relief of the distressing pain.

In the instance herein reported, there were undivided cranial nerves supplying areas adjacent to the point of carcinomatous involvement, but as far as could be determined there was never a complaint which would indicate transmission of the painful impulses over these pathways. Furthermore, all stimuli applied to skin of the left submaxillary region and the left side of the neck as far down as the supraclavicular fossa provoked no response. Bimanual pressure on the carcinomatous mass of the submaxillary region relieved the pain for the moment, only to cause an increase in its severity upon release.

Further experiences with similar lesions has shown that when dividing the cervical nerves a contralateral hemicordotomy should also be performed. If painful impulses pass over the sympathetic fibers of the neck it is almost a certainty that they enter the central nervous system at the first and second dorsal segments. It is therefore more rational to combine the cordotomy with the cervical rhizotomy rather than to perform a second operation on the cervical sympathetic trunk and the carotid plexus.

NON-TRAUMATIC PERFORATION OF COMMON BILE DUCT*

intrahepatic bile duct with escape of bile from the surface of the liver. All of these cases had mechanical obstruction. This condition, as well as the so-called "weeping" gall bladder, would seem to differ etiologically from the one reported here.

Burden[3] has reviewed the work of others on the anatomy of the extrahepatic bile ducts and shown by his own original study that these structures may well be subject to intrinsic pathology. To his findings we may well look for a plausible explanation of pathological rupture. He has shown that the biliary duct wall contains many sacculi into which empty innumerable glands. These glands extend well toward the outer surface of the wall. Normally these sacculi contain no bile, being filled with the mucoid secretion of the glands.

It seems altogether possible for infection to obtain entrance with a resultant abscess or ulceration which finally causes the complete perforation which must have existed in this case.

[3] Burden, V. G. Histologic and pathologic anatomy of hepatic, cystic and common bile ducts. *Ann. Surg.*, 82: 584–597, 1925.

* Continued from p. 103.

NON-TRAUMATIC PERFORATION OF COMMON BILE DUCT*

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THE lesion mentioned in the caption is apparently exceedingly uncommon. We were able to find reference to only one other case in the literature; that mentioned by Bailey.[1] The rarity of this acute emergency seems to warrant its report in some detail.

Case No. H-16242. Mrs. C. C. a Mexican girl, aged twenty-three, was admitted to the Medical service about 4:00 A.M. November 15, 1930, with a diagnosis of acute gastritis.

The immediate history was to the effect that she had been taken ill suddenly about 6:00 P.M. the evening before with excruciating pain in the epigastrium, extending through to the back. She vomited once, and nausea with wretching continued throughout the night. The pain increased in severity until it became unbearable.

The past history included several previous attacks of a similar nature during the past four years, though none approached the severity of the present one. Fatty foods seemed to cause some distress, and gaseous eructation afforded some relief. There was never any jaundice or clay-colored stools.

Examination upon admission showed an adult female Mexican of slight stature in good general condition, but restless and evidently acutely ill and suffering much pain. The abdomen was flat with marked tenderness and some rigidity in the upper right quadrant. There was no icterus. Admission temperature 97°F., pulse 96, respirations 22; white blood cells 11,500 with 80 per cent polymorphonuclears. The rigidity rapidly increased as did the pulse and temperature. Operation was advised on the diagnosis of perforation of the gall bladder, possibly of a duodenal ulcer.

Consent could not be obtained until about 10:00 P.M. that evening, twenty-eight hours after onset, at which time the temperature was 102.2°F., pulse 120, 24 respirations; W.B.C. 15,000, 82 per cent polymorphonuclears.

Operation: Spinal anesthesia. Upon opening the abdomen through an upper right rectus incision free clear bile was found filling the subhepatic fossa. This was sponged out but very slowly reappeared. The gall bladder was chronically inflamed with thickened walls and was filled with innumerable small stones (129 were counted). There was no point upon it which leaked bile. The stomach and duodenum were normal. The peritoneum covering the common duct, portal vein and hepatic artery, was edematous, evidently having been dissected up by the presence of escaping bile somewhere beneath it. No stone or point of induration could be felt along the course of the common duct. The gall bladder was opened, the stones removed and since bile flowed freely through the cystic duct a tube was placed in the gall bladder and held by a double purse string suture. A cigarette drain was placed at the foramen of Winslow and the incision closed to drainage.

Postoperative Course: A large amount of glucose and saline intravenously and one direct blood transfusion were necessary to carry the patient over the following five days during which a stubborn peritonitis existed. Recovery then proceeded slowly but smoothly.

COMMENT

The picture of his case reported by Bailey is quite similar to that of ours both as to the immediate acute history and in operative findings. Careful search did not reveal the perforation which was discovered at autopsy to be located posteriorly at the junction of the cystic duct with the common.

Woodruff Smith[2] has collected 11 cases and reported one of his own of rupture of an

[Concluded on p. 102.]

[1] Bailey. Emergency Surgery. 1930. 1: 103.

[2] Smith, Woodruff. Rupture of intrahepatic bile duct with fatal peritonitis. *Ann. Surg.*, 83: 55–68, 1926.

* From Receiving Hospital. Submitted for publication October 14, 1931.

HYDRAULIC VICIOUS CIRCLE AS IT DEVELOPS IN THE INTESTINE

EFFECT OF INTRAINTESTINAL PRESSURE ON THE PATHOLOGY AND PHYSIOLOGY OF THE BOWEL*

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A DISTENDED intestine promptly becomes the site of a hydraulic vicious circle, and the thin wall of the intestine with its poorly protected circulation makes it particularly vulnerable to its strangulating effects. The term "strangulation" has always carried with it the suggestion of blood stasis in the intestine, and it is there that it has been most frequently studied and discussed.

In strangulated hernia, hydraulic vicious circle is a very prominent factor. It is the basis of most of the pathology in the loop of obstructed bowel and is the cause of the rapid production of gangrene which led surgeons, fifty years ago, to say, "Never allow the sun to set on a strangulated hernia." In fact, the whole pathology in a (strangulated) loop of intestine, whether from a hernia or other mechanical cause, is due to the mechanics of hydraulic vicious circle. The initial pressure upon the neck of the hernial sac is very seldom sufficient to stop immediately all circulation into the contents of the sac. Often pain does not develop in a retained hernial loop until several hours after the patient finds himself unable to return it to the abdomen. During this period, the constriction at the ring is not sufficient to produce strangulation. It is, however, tight enough to obstruct the flow of the intestinal contents. The peristaltic action above forces intestinal contents into the loop, but the constriction is so snug that it cannot pass out of it. Thus intestinal contents accumulate until the pressure within the loop establishes a hydraulic vicious circle, with all its consequences.

Once this vicious circle is established, it proceeds exactly as in abscess, and in appendicitis. The material in the loop increases, the effusion increases, and the pressure rises until the circulation in the walls of the intestine is entirely obstructed, and complete strangulation results. The thin wall of the intestine offers little resistance to the closure of these blood vessels.

In abscess, where there are no definite walls, the progress of strangulation is slow; and the walls of the appendix, being thicker, offer much more resistance to the pressure of the accumulating fluid. In the small intestine, on the other hand, the blood vessels having little to support them collapse very quickly. Any gas which may be present in the loop is quickly forced out into the circulation and carried off by the lungs. The effusion always found in the sac of a strangulated hernia is evidence of the pressure upon the walls of the intestine and upon its capillaries, with resulting effusion, from both the outside and inside of the gut. This accounts for the fluid always present in the sac of a strangulated hernia.

Bacteria, by their constant presence in the intestine, play the same role as in the appendix. There is congestion, lack of oxygen, the presence of anaerobes and facultative anaerobes, and infection is very prompt and progresses very rapidly.

The mechanics of obstruction of the intestine in other conditions than hernia is practically the same. When caught under a band of peritoneum it is identical. Volvulus will often produce almost complete strangulation in the same manner. Intussusception has some varying symptoms

* Submitted for publication December 17, 1931.

according to the portion of the alimentary canal involved, but the underlying causes are the same, hydraulic vicious circle, and the results are the same, a gradually developing gangrene.

When an intestinal obstruction develops without producing a loop, as from a band, the hydraulic vicious circle is only partially developed, depending upon the amount of intestine above the obstruction. There will always be more or less interference with the circulation, but if the obstruction is near the stomach, regurgitation will promptly relieve the distention, so that there is but little direct interference with the circulation. For this reason an obstruction in the duodenum will produce copious vomiting, with rapid dehydration of the body; the secretions from the pancreas and liver add enormously to the pouring out of fluid into the intestine, all being expelled by vomiting. But there is less evidence of strangulation here. If this obstruction is low down in the small intestine, the long alimentary tube through which the antiperistalsis must work fails to relieve the intraintestinal pressure, and enough pressure will eventually be produced to cause necrosis and gangrene by the pressure of the distention itself shutting off the circulation.

In every case of intestinal obstruction, interference with the circulation is the most important factor. Whether the toxic symptoms be due to the formation of actual toxins (Whipple, Morton, etc.), or whether they are dependent upon dehydration and depletion of the chlorides, or both, the principal factor in the impending tragedy is the interference with the blood supply through the establishment of a hydraulic vicious circle. The interference with the circulation aids in producing dehydration by effusion into the intestine above the obstruction and together with infection produces necrosis and gangrene which is followed by rupture and peritonitis. Peritonitis following rupture is of course the common cause of death in intestinal obstruction.

Many workers at various times have referred to the obvious disturbance of the circulation and consequent impairment of function occurring in the walls of the hollow viscera as the result of distention from increased intravisceral pressure. Particularly with reference to the intestine and appendix there have appeared during the past few years a number of papers dealing rather specifically with various phases of this problem. It seems, therefore, appropriate to review this subject in an attempt to correlate the various data obtained with reference to the clinical conditions in which such intravisceral pressure may be significant.

In 1907,[1] I made a number of observations on the blood flow in the bowel wall as affected by varying pressures by means of a light within the lumen of the small intestine. It was observed that with distention of the intestine by a pressure of 30 mm. of mercury some capillary streams were arrested; at 60 mm., small veins were arrested, and in most veins the current was slow; at 90 mm., all blood streams were moving slowly, and many, but not all, currents were changing direction frequently; at 130 mm. pressure all circulation ceased, and there was some oscillation of corpuscles but no progress. The following conclusion was made at that time: The demonstration seems complete that distention of the gut (or of other hollow viscera) interfers with the circulation in its wall, and allows infiltration and effusion to take place into its walls and lumen and any other open spaces which may come within its influence. The return circulation is retarded at comparatively slight pressures. Effusion follows, as in all obstructions to venous flow. As the average venous pressure in the intestine under ordinary circumstances probably varies from 4 to 10 mm. of mercury, any pressure beyond that will offer some resistance to the return current.

In 1926, Van Beuren[2] studied the pathologic changes occurring in distended loops of bowel and found that the characteristic

features were areas of hemorrhagic infarction on the antimesenteric surface of the intestine, with varying degrees of necrosis to perforation occurring in these areas depending on the duration of the distention. He stated:

The mechanism of this infarction appears to be as follows: Distention of the intestine increases its diameter. Any increase in its diameter is tripled in its circumferential measurement. In other words, if the diameter of an intestine is increased by distention from 1 cm. to 3 cm., its circumference is at the same time increased from 3 cm. to 9 cm. Thus, the difference in the diameter is only 2 cm., while the difference in the circumference is 6 cm. A moderate increase in diameter, therefore, results in considerable stretching of the wall. The intestinal vessels pass between the layers of the wall along its circumference from their origin at the mesenteric border to their terminal anastomoses at the antimesenteric surface, becoming progressively more thin-walled and more narrow of lumen. Because they are elastic the stretching of the intestinal wall from distention still further thins the vessel walls and narrows the vessel's lumen like a stretched rubber tube. At the same time the pressure from within the intestine tends to flatten out the vessel's lumen. The narrowing of the vessel's lumen and the thinning of the vascular wall are maximum at the antimesenteric surface of the intestine where the terminal anastomoses occurs; and, the distention pressure being constant throughout the lumen of the intestine, the maximum effect is seen at the antimesenteric surface where a union of the three factors of pressure, thin wall and narrow lumen finally results in obliteration of the vessel. This obliteration occurs sooner in the vein than in the artery on account of the less resistant wall. The blood continues to pour through the arterial vessel until the pressure against the obliterated vein suffices to rupture the vessel wall and permit extravasation and coagulation. Finally, the pressure occludes the artery as well as the vein. The area of tissue supplied by these terminal vessels is thus deprived of circulating blood and necrosis occurs. This necrosis is usually first evident in the submucosa and inner muscular coat, but rapidly extends to the other coats of the intestinal wall, and perforation may occur within twenty-four hours after the discoloration due to the hemorrhagic infarct has been first noticed.

In 1927, Gatch, Trusler and Ayers[3] studied the effect of intestinal distention on the circulation of the bowel by recording the effect of such distention on the rate of blood flow in the returning veins. Their observations in general were confirmatory of Van Zwalenburg's, but in addition, afforded an estimate of the degree of circulatory impairment at different levels of pressure. They showed that the blood flow through the bowel wall decreases as the distention increases, and ceases when the pressure within the bowel equals the systolic blood pressure. This result has been confirmed and amplified by Dragstedt, Lang and Millet,[4] who have shown that distention causes the greatest interference with the circulation of the duodenum, and the least with that of the colon. They correlated this variation in susceptibility with the variation in the vascular distribution in different portions of the intestine pointed out by Eisberg.[5]

In 1930, Burget[6] and his co-workers made observations on the pressure developing in closed loops of intestine and noted pressures of 0 to 56 cm. of water. They noted necrosis occurring in the wall of loops distended by pressures of 25 to 30 mm. of mercury.

From the foregoing and many similar observations it is clear that the distention caused by obstruction, etc. can lead to varying degrees of circulatory disturbance in the bowel wall, and if severe to necrosis, ulceration and perforation. The mechanism and the nature of the pathologic changes developing are fairly clear. It is important, however, to consider what functional changes in the bowel wall may occur as the result of distention.

Effect of Distention on Intestinal Motility. It is well recognized that a certain degree of intraenteric pressure will act as a stimulus to peristaltic activity. In excised loops of guinea pig intestine Henderson[7] found pressures of 15 to 25 mm. of water to

be effective. As the pressure is increased, however, motility becomes impaired and finally ceases altogether. The following statement from Alvarez and Hosai[8] expresses the prevailing view:

> Hotz concluded, therefore, that injury to the muscle in peritonitis is due, not to toxins, but to distention by gas. The gas accumulates when absorption is impaired. As Usadel showed, distention of the gut closes not only the arterioles that bring necessary blood to the muscle but also the venules of the portal system, which normally carry the gas away as fast as it is formed. It can easily be seen, then, that once gaseous distention and muscular paralysis appear, they are likely to get worse and worse through the formation of a vicious circle.

Effect of Distention on Intestinal Secretion. Comparatively few observations have been made of the effect of intraenteric pressure on intestinal secretion. Herrin and Meek[9] studied the effect of distention on dogs with varying types of intestinal fistulae. On distending the intestine by means of balloons inflated to a pressure of 80 to 90 mm. of mercury they noted a very marked increase in the secretions from the fistula. As much as 550 c.c. of fluid was formed in a fistula 20 cm. long during the course of twenty-four hours. They state: "Distention is a strong stimulus to intestinal secretion and in obstruction this must work in a vicious circle."

Effect of Distention on Intestinal Absorption. Considerably more interest has been shown in the question of the influence of intraenteric pressure upon the absorption by the intestine of substances that may be present in its lumen. It has long been known that the normal mucosa has the ability of selectively absorbing many nutritive materials and of rejecting or not absorbing other substances not especially different in chemical and physical properties of solubility, permeability, etc. This selective ability of the mucosa, highly specialized as it is, might be presumed to be relatively susceptible to changes of intra-intestinal pressure.

In 1919 Dragstedt, Dragstedt, McClintock and Chase[10] reported a number of experiments which demonstrated that distention of the intestine operated to increase the absorption of toxic materials from the bowel lumen. It was shown that animals could tolerate closed obstructed loops of intestine containing highly toxic material if distention of the loop was counteracted by treating the intestinal mucosa with astringents, and conversely that adding substances like hypertonic magnesium sulphate to such loops which would provoke distention would be followed by intoxication of the usual type. More recently this was demonstrated in a different way by L. R. Dragstedt[11] who prepared closed intestinal loops in such a manner that the lumen of the loop could be aspirated at intervals by a needle thrust through the abdominal wall. In such animals it was observed that the onset of unfavorable symptoms occurred simultaneously with the development of considerable pressure in the loop, and that aspiration of a portion of the loop content, with resultant decrease in pressure, caused a relief in the symptoms. This experiment has been repeated and confirmed by Burget[6] and his co-workers, who have made the additional suggestion that part of the unfavorable symptoms present when the loop is under pressure may be reflex in character.

In 1924 Stone and Firor[12] studied the effect of intra-intestinal pressure on absorption from the lumen of the intestine. The following quotation from their article details their observation:

> Our attention was now turned to the way in which changes of pressure within the lumen of the bowel may affect the absorption of substances present there. It is perhaps well repeated here the observations made by ourselves and others in the behavior of the material found in experimental loops of jejunum. As has been said, this contains a highly toxic element, which when injected intravenously, with proper controls and precautions, causes the death of healthy dogs with a typical syndrome, analogous to that seen in obstruc-

tion. The generally accepted view is that this element is the lethal agent in obstruction, and that its absorption is the cause of death. But if this material be introduced into the lumen of the unobstructed bowel, either by feeding tube or injection through the bowel wall, it is quite innocuous. In other words, it is not absorbed. To throw light on this particular phase, a series of experiments was made with India ink, which may be summarized as follows: (1) Ink was injected into the lumen of the normal intestines exposed by laparotomy, and the wound closed. Such abdomens were reopened at varying intervals afterward and careful search made for any evidence of absorbed ink in the intestinal lymphatics, the mesenteric and retroperitoneal glands, and the liver. None was found. (2) A partial occlusion of the lumen in the duodenum just distal to the papilla of Vater was made by seroserous sutures, kinking the bowel into a sort of sigma shape. The same thing was done in the jejunum about 20 cm. below the first kink. This gave a loop partially, but not completely, obstructed at each end. Into this loop, India ink was again injected. At intervals, the lymphatics, glands, and liver were examined for ink, and none was found. (3) A tie of string (but not thick silk) was placed about the duodenum below the papilla and tied down very hard so as to close completely the lumen. The two sides of the sulcus caused in the bowel walls by this ligature were united by seroserous mattress suture, thus burying the constricting ligature about the bowel. Another hard tie, similarly covered, was placed about the jejunum some 20 cm. below the first. Thus a double complete obstruction and an isolated loop were formed. Into this closed loop was injected again some India ink. We expected these dogs to die. To our surprise some of them survived the initial critical period and seemed to be alright. The abdomen was then opened, and it was found that both ligatures about the bowel had cut through into the lumen and the obstruction was thus relieved spontaneously. The point of greatest interest, however, was that the lymph glands draining the temporarily completely obstructive loop were black with ink, visible both to the microscope and the naked eye.

Comment on this group of experiments will be limited at this time to pointing out that India ink, like the toxins from obstructed loops, is not absorbed when injected into the normal bowel lumen; it is not absorbed when the lumen is narrowed and kinked, but still patent; it is absorbed, however, when complete obstruction exists even for so short a period of time that the animal does not succumb to the obstruction. A possible explanation of these facts might be that pressure within the lumen must reach a certain level before the ink is absorbed through the wall of the bowel, and as long as the lumen was even partially patent, this level was not reached. It is interesting to note also that the dogs which absorbed the ink in these experiments still survived. It may be assumed that they also absorbed toxins, but that the release of the obstruction occurred before a lethal dose was attained, and with the release of obstruction, pressure in the bowel fell, and absorption ceased.

The next series of experiments was performed upon living excised loops of lower duodenum and upper jejunum, obtained from dogs. The preparations were made as follows: The loops were excised without ligation of the stumps of blood vessels or lymphatics leading from the intestine into the mesentery. The mesentery was divided fairly close to the bowel. The loops were suspended in flasks of Ringer's solution, kept at body temperature over a hot water bath, and were discarded for further use as soon as failure of muscle contractions or change of color suggested that the tissues were losing their vitality. With such preparations several types of experiments were carried out: (1) A loop so prepared, closed at both ends by firm ligatures was suspended in the solution for forty-five minutes. At the end of this time the surrounding Ringer's solution was injected intravenously into a healthy dog. No effect of a toxic nature was noticed. (2) A loop so prepared was filled with known toxic content from a dog dying with an isolated obstructed segment of bowel. To one end of this loop a hand-operated pressure bulb was attached by a rubber tube, and the other end of the loop was tied off securely. The preparation was then suspended as in the other experiment, and pressure alternately applied and relaxed, distending the loop with toxin in it in cycles that might be approximately like those of peristalsis. After forty-five minutes the fluid in which the loop was suspended was injected intravenously into a healthy dog and produced death with the typical signs and

symptoms caused by the toxins of obstructed loops of bowel. We interpret these findings to mean that toxin does not pass through a suspended living loop of bowel without some intraintestinal pressure, but does pass when such pressure exists within the lumen.

Gatch[13] has recently reported experiments which seem to clarify many of the apparently contradictory observations on the effect of varying intraintestinal pressures on absorption. Because of the importance of his observations the following quotation from a recent article of his is given:

A ligature is tied about the small intestine, and at a point one to two feet from this ligature the bowel is cut across and a glass cannula is introduced and tied in place so that a segment of bowel is isolated between the cannula and the ligature. The cannula is connected with a pressure apparatus. The blood pressure is recorded. With the segment of bowel outside the abdomen the pressure within it is now elevated till it equals the systolic pressure of the animal. As we have already explained this produces a complete anemia of the bowel. Now we introduce into the bowel a large dose of nicotine or potassium cyanide. Next we gradually lower the pressure within the bowel. There is no sign of absorption of the poison till the pressure reaches about half the systolic pressure. At this degree of pressure there is rapid absorption of the poison, clearly shown by a sudden and great elevation of blood pressure, if nicotine is used, and by a great increase in respiration if potassium cyanide is used. If now the same experiment is repeated except that the bowel, distended to the height of systolic pressure, is replaced within the abdomen, the animal shows immediate signs of absorption. Thus while the distention of the bowel prevents or diminishes direct absorption into the blood stream, it probably increases absorption by way of the peritoneum, because effusion can take place more readily through a thin and damaged bowel wall than through a bowel wall uninjured and of normal thickness. By this method it can be shown that absorption from the intestine varies inversely as distention of the intestine, or stated in other terms, the absorption decreases as the circulation through the bowel decreases, till with the onset of gangrene all absorption must be transperitoneal. From an incarcerated loop or from any loop, the mesenteric vessels of which are obstructed, the absorption must be transperitoneal from the very onset, because here the mesenteric veins of the loop are obstructed very soon. From the free bowel above the site of obstruction the absorption by way of the mesentery will decrease as the distention of the bowel increases. Since observers are pretty well agreed that the toxins from the obstructed bowel are but slowly absorbed through an intact mucosa, and since injury of the mucosa does not occur till a rather high degree of distention has been reached, which would interfere with the circulation of the bowel wall, it follows that the chief route of absorption must be transperitoneal and that the chief absorption of toxins in intestinal obstruction occurs rather late in the course of the disease, after well-marked distention of the bowel has occurred.

To summarize, there are numerous clinical and experimental observations in accord that in conditions of obstruction of the intestine, distention of a sufficient degree to produce alterations in the physiology as well as the pathology of the intestine may occur, that the resulting changes in motility and secretion of the intestine tend to further increase the distention by the establishment of a vicious circle, and that the distention may tremendously alter both the degree and the manner by which substances in the lumen of the intestine may be absorbed.

The bearing that these observations have upon the treatment of the various conditions in which distention may arise is not altogether clear. In case of a simple obstruction seen comparatively early the argument is not complex. There are, however, not a few reports of death, apparently due to toxemia, occurring rather soon after the relief of an obstruction that has existed for sufficient time to cause considerable distention. The earlier opinion that this could be explained by the absorption of toxic material after entering the empty and collapsed bowel below the obstruction

does not seem warranted by the observations previously mentioned, as it appears unlikely that such toxic material will be absorbed by the normal mucosa. On the other hand, as Stone[14] and others have suggested, the relief of the obstruction and the consequent fall in intraintestinal pressure may permit a rapid return of circulation through the bowel wall which may carry off into the general circulation poisonous material which may have penetrated the wall of the intestine during the period when the intestine was distended. This explanation would apparently necessitate the assumption that the transperitoneal absorption presumably occurring during the time of distention is of a less overwhelming nature than that via the mesenteric blood and lymph vessels after the distention is relieved.

It is not altogether an uncommon observation that apparently toxic symptoms may develop after the loops of bowel in the case of a strangulated hernia have been returned to the abdominal cavity from the hernia sac. It is quite possible in the light of Gatch's experiments to suppose that the strangulated loop while in the hernial sac is analogous to a loop of bowel distended while outside of the abdominal cavity to the degree that the only absorption possible is transperitoneal and that the hernial sac has not the absorptive capacity of the free peritoneal cavity. There is thus some justification for the position taken by various surgeons in advising resection of the bowel, which although apparently viable may have been damaged by the distention so that toxic absorption is possible.

There is the alternative of emptying the distended bowel by "stripping" by the method advised by Holden.[15] He places a test tube of considerable size in an incision in the bowel above the site of the obstruction. A ligature holds it in place at the flange. Through this, with the aid of a rubber tube to carry it off, he empties the entire bowel above the obstruction by very gentle stripping with the help of a suitable lubricant.

He reports excellent results. He avoids the shock and trauma of resection and removes the toxins effectively.

It seems probable from the foregoing that most of these problems will eventually be solved by these studies of the circulation in the bowel wall, studies of strangulation and *hydraulic vicious circle.*

Dehydration undoubtedly is the cause of death in many patients. Dehydration from vomiting, from lack of fluid intake, and the dehydration from shock, preoperative, operative, and postoperative, all add to the dehydration. These patients need quarts of salt solution and glucose. Many a patient has died from insufficient hypodermoclysis or intravenous infusion, or even blood transfusion.

Still there remains the positive evidence that the contents of experimentally obstructed loops is a deadly poison when administered to other animals. And it seems evident that many patients have died from the absorption, postoperatively, of this toxin.

The foregoing experiments in absorption with different degrees of pressure in the intestine explain much of the mechanics of this problem.

During the height of the obstruction the intraintestinal pressure, both in the loop and above it, is so high that the veins, capillaries, and lymphatics are all closed, and there can be no absorption. As already shown, when fully distended there can be no absorption from the intestine directly, only transperitonealy. After the obstruction is removed there is gradual relief of pressure, but the sluggish bowel needs some time to rehabilitate itself and be entirely relieved of distention. Congestion, deoxygenation, edema and infection are not immediately removed. In other words enough distention continues for some time to favor more rapid absorption than normal. As already shown moderate distention favors absorption in the presence of comparatively adequate circulation.

This moderate distention favors rapid absorption. The congestion and deoxygenation from poor circulation increase permeability of the capillaries. Complete

distention arrests the absorption of toxins but favors their development and accumulation. The moderate distention which follows the relief of obstruction favors a rapid and overwhelming absorption of the toxins directly from the intestine where they have accumulated. The impaired circulation is at the bottom of all. From this study does not the procedure of Holden[15] seem reasonable and encouraging? By gently emptying the bowel he relieves the circulation, restores normal capillary function more promptly, and removes toxic and infective material. Prompt restoration of adequate circulation is the important result. It is obvious that he must avoid trauma. When carefully done there should be little shock from this procedure.

Meanwhile, all the conditions, circulatory, collapse, shock, toxemia, dehydration, call for copious infusions of fluid hypodermically and intravenously. A well-filled heart has tremendously increased power over a half empty one, and capillaries cannot function properly without an adequate supply of blood and oxygen. Kidneys cannot secrete, nor liver detoxicate when blood pressure falls below a certain height.

We must bring back the blood pressure, and for this, the all-important remedy is an abundance of fluid. Begin before the operation, continue during the operation and then still continue.

Of course peritonitis kills most patients with obstruction, and here again fluid is the trump card.

From these studies we must conclude that both dehydration and toxemia are factors in the cause of the postoperative deaths. When obstruction is high up in, or near, the duodenum there will be a copious outpouring of fluids and chlorides from the liver and pancreas, as well as from the duodenum and stomach by vomiting, while in obstruction in the ileum, or near the colon there will be much less vomiting, but a greater accumulation of toxins and the products of infection. The length of bowel before the stomach is reached will prevent the fluid from reaching the stomach readily, and there will be correspondingly liberal reabsorption of fluid. For the same reason the greater stagnative and circulatory interference will favor formation of toxins. The more extensive bacterial flora, the congestion and deoxygenation are all important factors.

A most instructive study of the mechanics of intestinal obstruction came to me a few years ago in a patient with intestinal obstruction from a large gallstone which had ulcerated into the intestine. This stone, smooth and egg shaped, was just large enough to obstruct the small intestine and still allow the peristalsis to move it down gradually. It had taken approximately a week to reach the ileum where I found it. The distended bowel above it was congested to the point of blueness near the obstruction, but faded to an intense redness a few inches away. The congestion and distention continued upward however, for practically the entire length of the bowel. Near the point of obstruction the intestine was filled with fluid. Near the stomach it was being constantly emptied by regurgitation and vomiting.

The man was ravenously thirsty and evidently dehydrated. He called for water constantly and would promptly vomit all he drank, and seemingly more. He would then immediately call for more water. He had continued thus for several days.

The mechanics were evident. The obstruction was just enough to hold accumulating fluid of secretion, effusion and filtration above it. This distended the bowel to its capacity, stretching the walls and slowing the circulation to an intense congestion. This retarded circulation plus the deoxygenation of congestion increased the capillary permeability (Krog,[16] Landis[17]), allowing an increased outpouring of fluid from the circulation, resulting in the copious vomiting and dehydration.

At the same time it illustrated the fact that the 10 to 15 feet of intestine above this point were sufficient to hold a large quantity of fluid and gas in the distended congested bowel under dangerous pressure, but not sufficient to produce complete strangulation, necrosis or gangrene.

Let us assume that the intraintestinal pressure approached 15 cm. of water. Antiperistalsis would empty some of the contents into the stomach and the pressure would then be lowered to say 8 or 10 cm., just enough to allow capillary circulation with difficulty and great congestion. In a short time the additional accumulation would cause a repetition of the same program.

All the time the peristalsis and the hydraulic pressure were slowly moving the stone onward, steady pressure forcing enough tissues to give way to allow an increase in the diameter of the intestine sufficient to allow the stone to travel slowly downward.

This slow movement of the obstruction relieved the circulation just above it sufficiently to prevent complete strangulation or even infection.

Evidently this area just above the obstruction can withstand stasis up to practical strangulation and arrest for a short time, but if the obstruction is complete as from a peritoneal band a breakdown with necrosis and gangrene results, unless the obstruction is near enough to the stomach to permit antiperistalsis to empty it sufficiently easily to prevent the intraintestinal pressure to reach the point of permanent arrest of circulation in the bowel wall.

Had this stone in its downward movement arrived at a point of bowel sufficiently narrow to arrest it permanently, strangulation, infection and necrosis would have followed.

If on the other hand he could have withstood the dehydration long enough to allow the stone to reach the colon, without finding an impassable stretch, he would have recovered as many other patients of this type have.

In this case incision, easy removal, and copious hypodermoclysis were followed by a prompt recovery.

The mechanics of hydraulic vicious circle were there and beautifully illustrated, but the circle was never completed because one arc of it was movable.

I am proud to acknowledge my indebtedness to Carl Dragstedt for very material assistance in preparing this paper, and to Maurice Visscher for advice, suggestion and encouragement.

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PHLEGMONOUS GASTRITIS*

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GASTRIC phlegmon has been known since 1620 when the circumscribed form of the disease was first noted by Varandaeus. The diffuse form was described in 1861 by Cruveilhier, and since then there have been numerous reports in the literature describing cases of each type. Sundberg, in 1919, published a comprehensive monograph on the subject and included a review of 215 collected cases, and Gerster, in 1927, reviewed an additional 48 cases. During the next four years 12 case reports have appeared and 1 new case is included in this report. In noting the number of cases reported and bearing in mind that the diagnosis of this interesting disease is very difficult and probably quite frequently missed, and that not all diagnosed cases are reported, we find that this subject cannot claim the great rarity attributed to it by most authors. However, the problems of diagnosis and treatment are still unsettled and, for this reason, all cases should be reported. From the increased material, aids to a more accurate and early diagnosis may be had and more satisfactory surgery performed.

We believe that exploratory needle puncture of the upper abdomen with immediate pathological examination of the material obtained and flat plate *x*-rays of the upper abdomen are essential in acute upper abdominal cases where the diagnosis lies

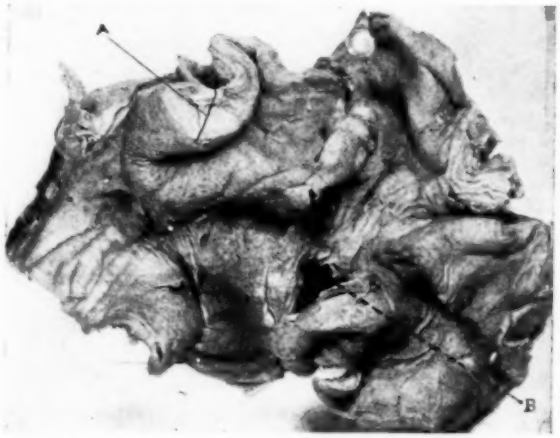

FIG. 1. Autopsy F. A. H. 276. Stomach laid open, showing thickened wall at A. Also flattening of rugae. B. Area from which microscopical sections were cut.

FIG. 2. Autopsy F. A. H. 276. Cross section of thickened stomach wall near pylorus, A. Greater curvature. B. Lesser curvature.

* From the Fifth Ave. Hospital, service of F. W. Bancroft. Submitted for publication October 5, 1931.

between perforated ulcer, acute pancreatitis, and gastric phlegmon. It is with the idea of encouraging the wider adoption of

circumscribed form, and the diffuse form. There may also be a combination of the two. In the circumscribed form there is a

Fig. 3. Autopsy F. A. H. 276. Low power view of section through stomach wall showing various coats. Increased thickness is due for most part to extensive cellular infiltration of submucosa.

these two diagnostic procedures that we offer the following report.

Phlegmonous gastritis is a severe inflammatory process of the stomach progressing to purulent infiltration and even necrosis of the stomach wall. There are two very definite forms of the disease: the

definite collection of pus in the stomach wall, in other words, a localized abscess. A typical case of this type was reported by Novak[17] and was cured by a partial gastric resection. The diffuse form is characterized by a more widespread inflammatory process which may include the entire stomach

and extend into the esophagus proximally and the duodenum distally. This form of the disease is twice as common as the circumscribed form and the results following operation are much less satisfactory because diffuse peritonitis is usually a complicating factor. A typical case of the diffuse form is reported in detail in this article.

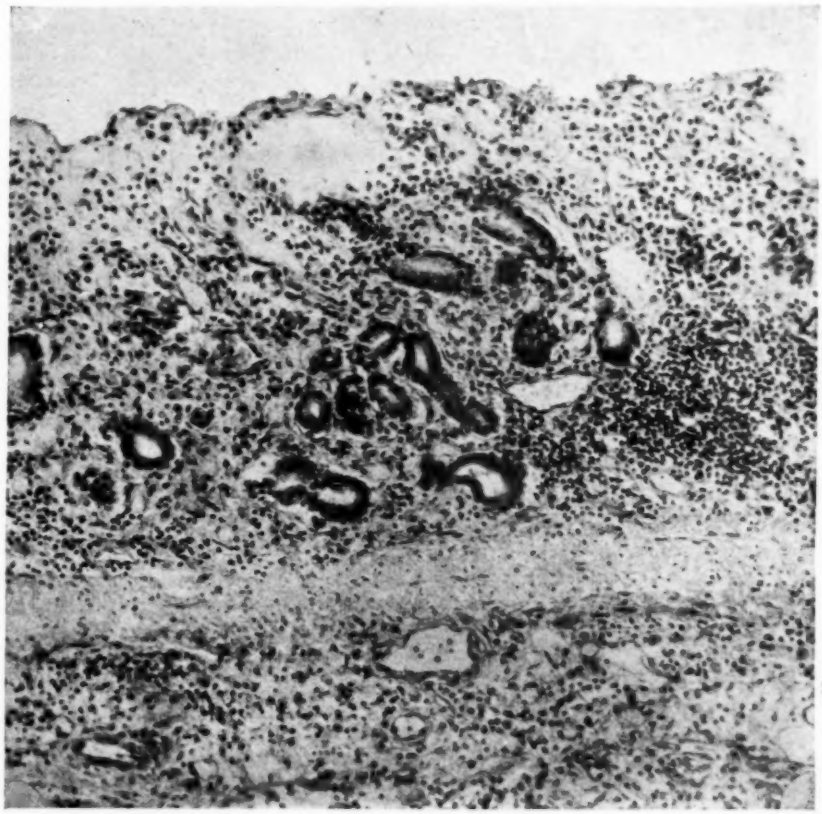

FIG. 4. Autopsy F. A. H. 276. High power view of stomach mucosa with broadened muscularis mucosa and strip of submucosa. Tissues are edematous and infiltrated with polynuclear cells.

As to etiology, much has been written, more has been inferred, and little has been definitely settled. It seems certain, however, that the origin of the inflammatory process may be either local or metastatic. In the first group would be included those cases in which there was present a gastric carcinoma or ulcer and those on which gastric surgery had been done. It has been suggested that gastric phlegmon in a mild form may be not at all an uncommon complication of extensive stomach surgery. Poisons and external trauma are doubtful local causes. In the second group we have the larger number of cases. As no break is found in the mucous membrane the origin of the disease is said to be metastatic, although it has been pointed out that streptococci may penetrate the mucous membrane without causing a local reaction at the point of entry. The inciting bacteria in this group probably enter the submucosa through the blood stream. Included in this group are the cases seen in conjunction with puerperal fever, septicemia, tonsillitis (Brooks and Clinton[3]), erysipelas, and furunculosis (Gerster[8]). Gastric phlegmon has also occurred in connection with smallpox, scarlet fever, and acute polyarthritis. Chronic alcoholism has been thought to be a causative agent and has been noted in about one-fifth of the cases (Albutt and Rolleston[1]). However, there are many cases of alcoholic indiscretion very few of which develop phlegmonous gastritis. Gerster[8]

mentions constitutional predisposing causes such as exhaustion from hard labor, alcoholism, chronic gastritis, hypo-

scribed in Albutt and Rolleston's "System of Medicine."[1] For a better understanding of the symptoms, course, and

Fig. 5. Autopsy F. A. H. 276. High power view of submucosa of stomach showing edema and polynuclear infiltration and increased vascularity.

acidity of the gastric juice, and also points out that direct contact with infectious material may be a cause. This latter condition would seem to prevail in cases noted in connection with stomatitis, pharyngitis, purulent bronchitis, drainage of abscesses of the oral pharynx, and extraction of carious teeth. It seems certain that a definite origin for most cases cannot be determined. The streptococcus is the bacteria isolated in most cases (70 per cent), although straphylococci, pneumococci, Bacillus coli, Bacillus subtilis, and Bacillus welchi, have also been noted.

The pathological picture obtained from a study of the post-mortem material is fairly uniform and is exhaustively de-

results of this usually fatal disease, a few of the main features of the pathological anatomy will be mentioned. The circumscribed form, pathologically, resembles the diffuse form except that the process is more limited. Grossly, the stomach wall is thickened up to eight or nine times its normal size. The stomach capacity may be increased, diminished, or unaltered. The stomach has usually a soft, thick, boggy feel. The serosa may be an angry red or covered with a layer of yellowish fibrin. The mucosa may be hemorrhagic or pale, but is usually smooth with a marked absence of rugae. Microscopically the mucosa shows an abundant round-celled infiltration between the gastric glands and there is

dilatation and cloudy swelling of the blood vessels with extensive degeneration and even necrosis of the secreting cells. The muscularis mucosae may be normal or irregularly swollen and infiltrated with round cells. The submucous coat shows the greatest involvement. It is extremely thickened and edematous and shows immense numbers of leucocytes and an abundant network of fibrin throughout its thickness. The blood vessels are dilated and the tissues of their coats swollen. Microorganisms are present in large numbers. The muscular coat is often very little altered but may occasionally be swollen and edematous. It is less often infiltrated with fibrin or serofibrinous pus. In a number of cases this muscular layer is degenerated, necrosed, or destroyed, allowing pus to reach the serosa. The serous and subserous coats may be unaltered or may show edematous swelling, purulent infiltration, and varying degrees of local peritonitis.

The symptoms of this acute abdominal disease are not characteristic. There is usually a history of previous gastric distress followed by the sudden onset of severe upper abdominal pain which is continuous and cutting, and shows a tendency to persist and increase. It is first localized and is increased by pressure in the epigastrium. Later, with the onset of peritonitis, the pain becomes generalized. Vomiting begins early in the disease and continues, becoming more frequent towards the end. Two patients whose cases are reviewed in this report did not vomit. Both were males: one was seventy-two years of age and the other a carcinomatous patient of sixty-two. Old age and debility may account for the absence of vomiting in these 2 cases. The vomitus consists first of a watery, mucoid material which later becomes bile-tinged

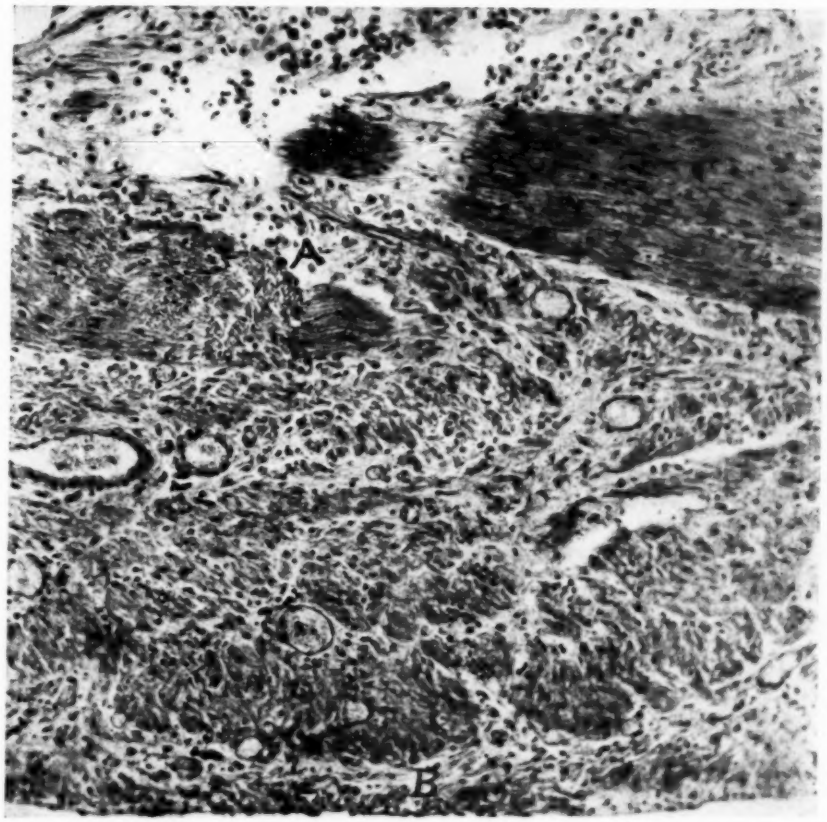

Fig. 6. Autopsy F. A. H. 276. High power view of muscularis (A) and serosa (B) of stomach wall. There is edema and polynuclear infiltration.

and then greenish. Frank pus has been reported. Fever may be absent, but the temperature is usually 100 to 104°F. The

Fig. 7. Preoperative *x*-ray.

pulse is at first full and strong, but later becomes thin and rapid. There is increased resistance in the epigastrium. Deininger (1879) noted a relief of pain when the patient was made to sit up. The patient appears acutely ill and is restless and anxious, later becoming dehydrated, and finally going into delirium and collapse. The white blood count is usually high: 20,000 to 30,000, with a correspondingly high polymorphonuclear count.

From a glance at the symptoms of this acute abdominal condition, it is clear that the diagnosis will be a difficult one to make because of the lack of any definite diagnostic sign or symptom. For this reason it is very rarely made before operation or necropsy. A perforated gastric or duodenal ulcer is most often suspected and acute pancreatitis is also a frequent preoperative diagnosis. Neuhoff[18] reports a case in which an abdominal puncture was done and a considerable amount of cloudy fluid containing streptococci was obtained. A similar procedure was done in our case and a thin, turbid, slightly reddish fluid was obtained. A typical history together with streptococci in a turbid fluid removed by abdominal puncture should lead one to suspect a gastric phlegmon, and would tend to rule out acute pancreatitis and perforated ulcer. It would seem logical to expect a very thick walled stomach to produce an area of increased density on an *x*-ray film, but the film taken of the case reported in this article was only suggestive of a thickened stomach wall. As far as I know, there are no other cases reported where *x*-rays were taken during the acute stage of the disease, and I would urge this procedure in all suspected cases. High fever and frequent vomiting of bile-stained watery material together with relief from pain on sitting up (Deininger) speak for gastric phlegmon as against perforated ulcer. A preoperative *x*-ray of the abdomen might give definite evidence of a perforated viscus, and a review of the films in cases which at operation proved to be phlegmonous gastritis might lend some clue to the *x*-ray diagnosis of this condition. With the abdomen open the diagnosis is often made or confirmed by aspirating pus from the submucous layer of the stomach wall.

The prognosis is grave. Death is the usual outcome in the extensive diffuse type. In the localized type the abscess may rupture into the stomach and a spontaneous recovery ensue or the involved portion of the stomach may be resected giving the case a better prognosis. Cases which have recovered after simple drainage of the abdominal cavity must be classed as spontaneous. Perhaps many others have recovered which were never diagnosed.

The most consistent complication and the immediate cause of death in most cases is a diffuse peritonitis.

The treatment is surgical, but the procedure carried out at operation will depend upon the type and extent of the disease. Gerster[8] reviewed 18 cases in which gastric resection was done. Of these, 8 patients

recovered (44 per cent), so that it seems clear that gastric resection for the circumscribed type of gastric phlegmon is the treatment of choice. In the extensive diffuse type, a resection would be futile, and in these cases a palliative jejunostomy and abdominal drainage seem advisable. Multiple incisions in the stomach wall down to the mucosa with adequate drainage has been advocated. Gastrostomy and gastroenterostomy have been done with very little reason or success. It has been suggested (Weinstein and Klein[28]) that the entire stomach be brought out of the abdomen, as in a Mikulicz operation for malignancy of the colon, and multiple incisions made through the serosa and submucosa for drainage and a jejunostomy done for feeding purposes. This procedure has never been done, but would seem logical for otherwise hopeless cases of extensive diffuse phlegmonous infiltration of the stomach wall. In our case the disease was very extensive, extending into the duodenum and esophagus and involving the entire stomach. A palliative jejunostomy was done and the peritoneal cavity drained.

CASE REPORT

The following is a summary of the history and findings in our case which is No. 12 in the table of reviewed cases:

Miss A. M., an Irish housekeeper forty-eight years of age was admitted to the Fifth Avenue Hospital on the service of Dr. F. W. Bancroft at 12.40 P.M., March 19, 1930. She was complaining of pain in the abdomen together with vomiting of six days' duration.

History. Symptoms began with a sudden sharp pain in the epigastrium. This pain rapidly shifted to the right lower quadrant and she began to vomit. Then the pain spread to the entire abdomen and the vomiting continued up to the time of admission. Her bowels had been moving regularly and she gave no history of previous indigestion or vomiting. Her previous history was essentially negative. She had not lost weight and gave no history of excessive use of alcohol. Her menstrual history was entirely normal.

Physical examination revealed an acutely and gravely ill woman lying quietly in bed and giving the typical picture of a generalized peritonitis. Her abdomen was slightly distended and rigid throughout. There was marked spasm of both rectus muscles, rebound tenderness throughout and definite skin hyperesthesia. The abdomen was typanitic except for dullness on percussion in the left upper quadrant. Rectal examination revealed tenderness in both fornices and the cervix was very tender on manipulation. There was no obliteration of the liver dullness. Flat plate *x*-ray of the abdomen did not show a definite mass or any evidence of intestinal obstruction.

Laboratory Data. Her temperature was 103°F., pulse 120, and respirations 24. Blood count: White blood cells 24,500, polymorphonuclears 96 per cent, lymphocytes 4 per cent, and non-lobulated polymorpho-nuclears 86 per cent. Coagulation time four minutes. Urinalysis: Acid reaction, trace of albumin, no sugar, occasional finely granular cast, occasional red blood cells, and a moderate number of white blood cells.

The case was seen by several of the attending surgeons. All agreed that the patient had a generalized peritonitis and each suggested a possible cause for it such as acute suppurative appendicitis, perforated duodenal ulcer, acute pancreatitis, etc. An exploratory laparotomy was definitely indicated from the findings and was performed immediately.

Operation. Before making an incision a lumbar tap needle was inserted into the left upper quadrant and about 1 cm. of turbid fluid was removed from the peritoneal cavity. A mid-paramedian incision was then made. Diffuse peritonitis was seen and a large amount of turbid fluid mixed with flakes of fibrin was evacuated. The appendix was first sought for and drawn up into the wound. The vessels seemed to be congested, but there was no evidence of any primary trouble there and its removal was considered inadvisable. The gall bladder was palpated and found to be normal. The duodenum was normal on palpation and no thickening of the pancreas was felt. The stomach from the pylorus almost to the cardia felt about 3 cm. in thickness. This was the only lesion that could be seen during the exploration and suggested a phlegmonous gastritis. There was no evidence of fluid in the lesser sac. It was thought advisable to do a jejunostomy in

order to relieve paralytic ileus and vomiting. This was done by inserting a No. 18 French catheter into the jejunum through a purse-string suture and inverting, as in a Witzel gastrostomy. The tube was brought out through the omentum and then through a lateral stab wound. One cigarette drain was placed through Morison's space and one lateral to the ascending colon. Two drains were placed to the right lumbar gutter, and two cigarette drains brought out at the upper and the lower angles of the incision. The peritoneum was closed and the wound loosely united with tension dermal sutures over buttons and packed with vaseline gauze.

Progress. Following the operation the patient's temperature steadily rose and twenty-four hours later it was 106°F., spiking down to 102°F. at mid-day. The following morning it reached 106.6°F. She was given saline therapy and was able to take some water by mouth without vomiting, but she presented a flushed face, bright eyes, cold extremities, rapid respirations, and the appearance of a doomed patient. She died three days postoperative.

The following is a report of the post-mortem examination performed by Dr. D. S. D. Jessup on March 22, 1930:

The body is that of a woman of about fifty, of medium frame and abundant adipose. To the right of the navel there is a vertical operative wound, 20 cm. long which is open down to the peritoneum. There is thin pus welling out from the bottom of the wound through openings of the peritoneum which occurs at several points. To the left of the navel there is a small opening with a drainage tube leading down through the omentum. The loops of the small intestine are matted together by a fresh exudate of lymph forming light adhesions. The appendix lies free and does not appear inflamed. The peritonitis extends through the whole cavity and over the surface of the liver.

The uterus is moderate in size. The tubes and ovaries are small and covered with exudate of lymph. The spleen is enlarged and soft with exudate on the surface. The heart is normal in size and the pulmonary valves are normal. The tricuspid admits three fingers. There is slight thickening along the edge of the mitral cusps. The aortic cusps are normal and near the cusps there is atheromata of the aorta. The coronary arteries appear normal. The heart muscle is normal. The left lung shows some fresh exudate of lymph over the lower lobe with marked congestion, and the upper lobe shows slight scarring at the apex. The right lung shows a large amount of fibrinous exudate over the surface. The liver is large, rather pale, and very friable on section. The pyloric end of the stomach shows increased thickness of the muscularis. The mucosa of the stomach is markedly injected with small areas of hemorrhage, but there is no break in the wall. The thickening is a diffuse process and on section there is an exudate of purulent fluid from the cut surface. The pancreas is normal in appearance. The small intestine is normal except for a few areas of congestion and the large intestine contains fecal matter in the upper portion, mucous in the lower portion, and also shows small areas of congestion. Both kidneys are normal in size, the markings are quite distinct, and the capsules strip quite readily. The adrenals show some congestion. The uterine canal is normal, the muscularis is very fibrous, and there is a small fibroid of the wall.

Bacteriological Examination. Smear of the lung shows many intracellular streptococci and a smear of the liver shows fewer streptococci.

Cultures taken of the upper surface of the liver, upper surface of the stomach, left quadrant, right quadrant, pericardial sac, and the heart muscle show gram positive bacilli, other slender gram positive rods (diphtheroids), and streptococci (?) not hemolytic. Aseptic cultures taken of seared spleen show hemolytic streptococci. Blood cultures were not done.

Anatomical Diagnoses:

1. General purulent peritonitis.
2. Acute fibrino-purulent pleurisy.
3. Congestion of the lungs.
4. Phlegmonous gastritis.

Microscopical Examination. The lungs at one point show marked congestion and edema. The pleura is thickened and covered by a positive fibrin mixed with polymorphonuclears. The underlying lungs show congestion. The heart muscle shows separation of the fibers by connective tissue growth. The aorta shows basic degeneration. There is fatty infiltration and congestion of the liver and old blood pigment, also some polymorphonuclear infiltration in Glisson's capsule. The kidneys are congested and there are inflammatory changes in some of the tufts. The pancreas shows some

Case No.	Sex	Age	Occupation	Probable Etiology	Prominent Symptoms	W. B. C.	Preop. Diagnosis	Operative Procedure	Autopsy	Bacteriology	Result	Author
1	M	72	.....	Followed operation for excision of ruptured duodenal ulcer	Sudden severe pain in upper abdomen. Abd. rigidity. No vomiting	17,300	Perforated ulcer	Excision of a perforated ulcer of the duodenum	Pulmonary edema and congestion. Phlegmonous gastritis. Peritonitis	B. welchi	Died	Morton & Stabins
2	M	49	.....	Developed during a streptococcus pneumonia	Symptoms of pneumonia plus tenderness in epigastrium	22,000	.....	.....	Lobar pneumonia. Phlegmonous gastritis	Lungs: Hem. streptococci. Stomach: Hem. streptococci	Died	Meyer, Brams, & Guy. Case No. 1
3	M	42	.....	Carcinoma of stomach. Bilateral pneumonia.	8 months gastric distress. Tender palpable mass in epigastrium	30,000	.....	Operation refused	Bilateral pneumonia. Diffuse phlegmonous gastritis	Not done	Died	Meyer, Brams, & Guy. Case No. 2
4	M	37	Clerk	Alcoholism. Ruptured gastric ulcer	Acute abdominal pain, vomiting and shock	.....	Perforated ulcer	Closure of perforation. Witzel type, jejunostomy	Peritonitis at operation	.....	Recovered	Weinstein & Klein
5	F	62	.....	Idiopathic	Severe abd. pain, vomiting, and diarrhea. Temp. normal	25,000	.....	.....	Phlegmonous gastritis	Streptococci and B. proteus	Died	Robb
6	M	62	Laborer	Carcinoma of stomach	4 yrs. epigastric distress. Acute severe abd. pain 2 days. No vomiting. Board-like abdominal rigidity	.....	Perforated ulcer	Exploratory. Drainage	Phlegmonous gastritis. Peritonitis. Carcinoma of stomach	Streptococci	Died	Schaefer
7	F	21	Dressmaker	Idiopathic	One year ulcer history. 3 days acute epigastric pain	.....	Covered perforation of stomach	Invagination of a 3 cm. necrotic area of ant. stomach wall & gastroenterostomy	.....	.....	Recovered	Paugger. Case No. 1
8	M	18	Locksmith	Chloride of zinc	Loss of appetite and pain 2 hrs. after eating. Sudden abd. pain, vomiting & chill	.....	Covered perforation of stomach	Exploratory. Drainage	Peritonitis at operation	.....	Recovered	Paugger. Case No. 2
9	F	43	.....	Carcinoma of stomach	5 yrs. dull epigastric pain. Sudden acute abd. pain 6 days after roentgen examination	.....	Covered perforation of gastric carcinoma	Partial resection. Braum anastomosis	Peritonitis. No phleg. gastritis. Avertin necrosis of rectal wall. Resected spec. showed phleg. gas	.....	Died 27 days P.O.	Paugger. Case No. 3
10	F	28	Housemaid	Carcinoma of stomach	6 mo. gastric discomfort then sudden severe abd. pain & vomiting. Tender swelling in epigastrium. Fever	.....	Inflammatory tumor of omentum with covered perforation	Billroth 1 resection	Op. specimen: Ca. & phleg. gastritis P. M.: Peritonitis & encapsulated abscess	.....	Died	Paugger. Case No. 4
11	M	18	.....	Partial starvation	.....	.....	.....	.....	Congested spleen. Diffuse phleg. gastritis	.....	Died	Mongin
12	F	48	Housekeeper	Idiopathic	Sudden sharp abd. pain & vomiting. Temp. 103°F. Pulse 120	24,500	Generalized peritonitis	Jejunostomy and drainage	Diffuse phleg. gastritis. Peritonitis	Hem. streptococci. B. Welchi & non-hem. streptococci	Died	Author
13	F	56	.....	Idiopathic	Vomiting at meal time for 20 yrs. Attacks of upper abd. pain with vomiting & fever	7,900	Chronic cholecystitis & cholelithiasis	Partial gastric resection & posterior polya anastamosis	Cellulitis of thigh. Lung infarcts & abscesses Phleg. gastritis. Peritonitis	.....	Died 20 days P.O.	Rankin & Miller

increase of stroma with edema. The adrenals show congestion and some round cell infiltration in the medulla. There is a fibrosis of the uterine wall and the endometrium is atrophic.

The esophagus near the stomach shows some edema of the stroma. The stomach glands extend up for a considerable distance and are covered by squamous epithelium for quite an area. The marked thickening of the wall of the stomach is caused by acute inflammatory exudate into the submucosa, this being made up of polymorphonuclear cells with fibrin and areas of necrosis. The inflammatory process goes through the muscularis where the muscle fibers are separated by edema and where there are many large mononuclear cells, these appear to be either monocytes or phagocytes. The serosa is involved in the inflammatory change and the superficial layer of the mucosa lining the stomach has the appearance of granulation tissue with many small thin-walled blood vessels. The spleen is markedly congested.

Microscopical Diagnoses:

1. Fibrino-purulent pleurisy.
2. Phlegmonous gastritis.
3. Streptococcus peritonitis.
4. Acute hepatitis.
5. Myocarditis.

SUMMARY

Of the 13 cases reviewed 9 patients were operated on and 3 recovered. In each case of recovery the disease was of the localized type and in one of these the diagnosis was made on inspection only. In 6 of the cases (46 per cent) there was an associated gastric carcinoma or gastric or duodenal ulcer. One case was precipitated by the ingestion of zinc chloride and another developed during the course of a streptococcus pneumonia. Starvation plus the eating of heavy rough grass is said to have caused a fatal phlegmon of the stomach (Mongin[13]). Seven of the patients gave a previous history of gastric distress. In 7 of the 9 patients operated upon a preoperative diagnosis of perforated ulcer was made. In one of the remaining cases a diagnosis of general peritonitis was made and in the other cholelithiases was the diagnosis. In 5 cases bacteriological studies were done and 4 showed streptococci and one Bacillus welchii. In 1 case the streptococcus was found in association with Bacillus proteus and in another with Bacillus welchii.

CONCLUSIONS

1. Phlegmonous gastritis is not as rare a condition as it was formerly thought to be. There are two forms of the disease, the diffuse and the circumscribed. The diffuse form is fatal; the circumscribed form is less so.

2. The diagnosis has never been made before operation or autopsy.

3. Abdominal puncture after the technique of Neuhoff[18] and the routine preoperative *x*-rays of the abdomen are suggested as additional aids to diagnosis.

4. Treatment must be surgical, the procedure elected depending on the type of the disease. Localized type: gastric resection; diffuse type: surgery offers the palliative relief of a jejunostomy.

5. The etiology is not clear, but in a large number of cases there is preexistent stomach pathology, often carcinoma or ulcer, which may provide for the easy entrance into the submucosa of the streptococcus, the organism usually isolated from the phlegmonous gastric wall.

6. All cases should be reported completely so that with increased material at hand the symptoms and diagnosis may be more clearly understood and the treatment improved. The surgeon when confronted with an acute upper abdominal inflammatory lesion should always consider the possibility of a gastric phlegmon.

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[For Remainder of References see p. 50.]

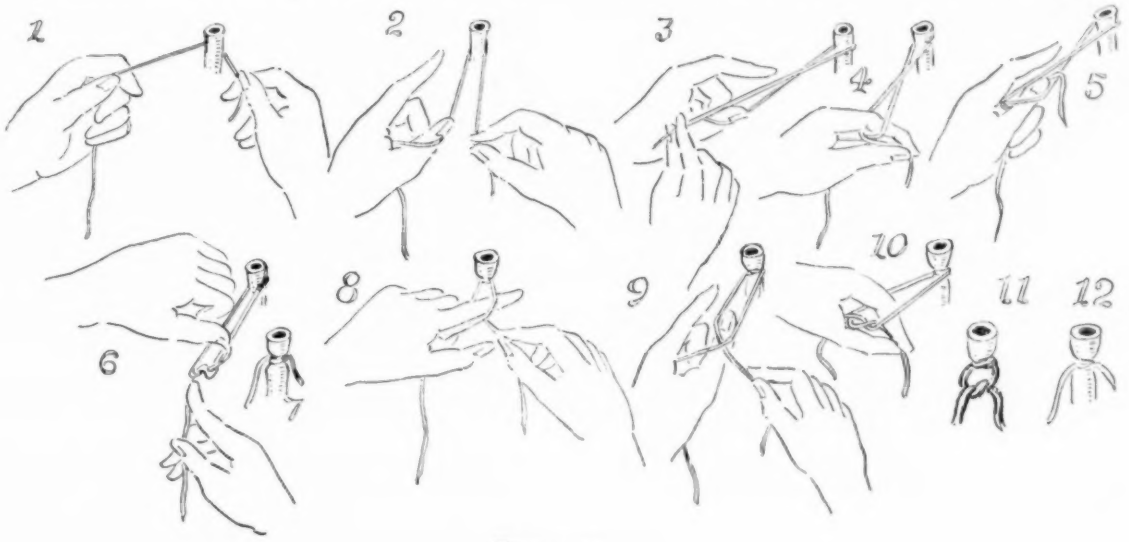
BLOOD VESSEL LIGATION TECHNIQUE

SUCCESSIVE STEPS IN TYING THE "GRANNY" AND "SQUARE KNOTS"*

SAMUEL I. WEINER, M.D.

CHICAGO, ILL.

THE technique of ligating blood vessels has become so refined and so standardized that perhaps one should offer an apology for discussing its details, but there are certain points in its performance which if kept constantly in mind by the surgeon, will often avoid serious accidents during and after an operation.



FIGS. 1–12.

1. The long end of the ligature is held in the palm of the left hand with the short end projecting between the thumb and index finger.

2. The short end of the ligature is brought around the vessel to be ligated with the right hand and is held between the tips of the thumb and index finger. (Fig. 1.)

3. With the left taut part of the ligature hugging the inner and volar part of the thumb of the left hand, the short end of the ligature is brought over to the apex of the angle between the thumb and index finger of the left hand. (Figs. 2 and 3.)

4. The left index finger is inserted into the loop thus formed, and the short end is crossed over the palmar surface of same towards the tip and supported by palmar surface of the adjacent thumb and brought up through the same loop. (Figs. 4 and 5.)

5. The short end is grasped by the right thumb and index finger and the first tie is completed by crossing the long end of the ligature over the short end, thus avoiding undue friction and breaking the ligature. (Figs. 6 and 7.)

To complete the "granny knot," the above steps are repeated in the same order.

To make a "square knot," at this stage, the long end of the ligature is brought over the outer and posterior part of the left index finger and the short end is brought across on the palmar surface of the index finger, thus leaving the latter in the loop produced, pointing downwards. (Fig. 8.)

1. The adjoining thumb pushes the index finger out of the loop and takes its place. (Fig. 9.)

2. The short end is then brought across

[Concluded on p. 89.]

* Submitted for publication October 26, 1931.

A MULTIPLE FILM CASSETTE

WITH A GRATING LOCALIZER TO AID IN A MORE PRECISE IDENTIFICATION AND LOCALIZATION OF RENAL CALCULI AT OPERATION*

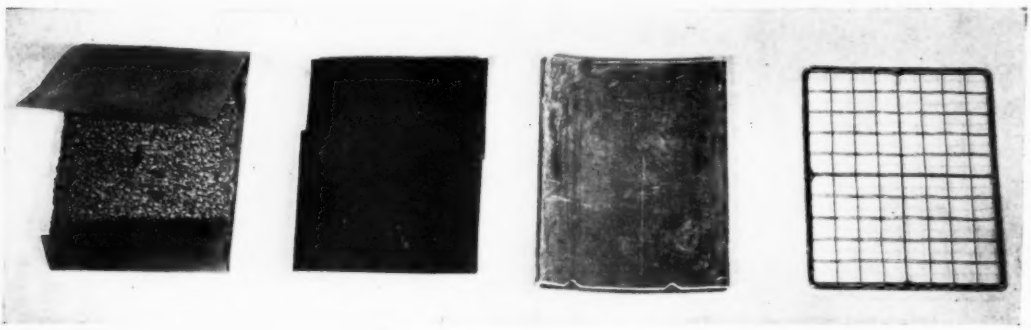
WALTER W. FRAY, M.D., AND WILLIAM T. HILL

ROCHESTER, N. Y.

A LOCAL kidney film at operation has been used for years by urologists for the double purpose of localizing a kidney stone and of ensuring the complete removal of multiple stones after lithotomy.

Quinby[1] (1925) was the first to point out the advantages of the film over fluoroscopy and actually demonstrate its practicability at the operating table. His method was simple. A small film (10 × 12.5 cm.) was wrapped in a sterile towel or slipped in a sterile rubber envelop and placed in the wound behind the kidney. Such a film bends readily, is difficult to insert in the wound, and lacks the rigidity necessary for proper manipulation of the kidney.

Benjamin[2] (1931) has recently described a cassette designed by Jaches. This resembles an ordinary cassette, but it is constructed on a miniature scale (3.75 × 4.75 inches). It is hinged in the usual manner of a cassette, is kept closed by two clasps at the opposite margin, and contains two intensifying screens. This cassette has the advantage of rigidity and permits a shorter exposure time.



A B C D

FIG. 1. Various parts of cassette and grating localizer (reduced 3½ times). A, Folded strip of film base. Within it is a thin layer of sponge rubber (portion of ordinary rubber bath sponge). Film base enables one to slip film pack into cassette without injury; sponge rubber effects necessary contact of fluorescent screen and film. B, Film pack, containing two films with a single fluorescent screen between them, protected from light by black paper. Only one of these films is affected by fluorescent light and two films of different roentgenographic densities result on exposure. Fluorescent screen is ruled off in centimeter squares with india ink. C, Slightly curved aluminum cassette. This is essentially an aluminum pocket without hinges or clasps. D, Centimeter grating, use of which is described elsewhere.

It appeared to us that the cassette method was capable of much greater development. The features desired in this cassette were (a) thinness, compactness, and rigidity to permit easy insertion in the wound; (b) shape to conform roughly with curvature of kidney; (c) elimination of troublesome hinges and clasps; (d) exclusion of light without the usual means of

[1] Quinby, W. C. A note on the localization of renal calculi by the aid of *x*-ray films made during operation. *J. Urol.*, 13: 59, 1925.

[2] Benjamin, E. W. Notes on the technique of *x*-ray control in the operating room. *J. Urol.*, 25: 165, 1931.

* From the Division of Radiology, Department of Medicine, School of Medicine and Dentistry, University of Rochester and the Strong Memorial Hospital, Rochester, N. Y. Submitted for publication December 1, 1931.

light-proofing of the cassette by felt; (e) foolproofness, rendering it impossible to have the cassette inverted at time of exposure or to lose orientation of film after development, i.e., to confuse upper with lower poles of kidney, etc.; (f) insurance of proper exposure (all using this method are familiar with the ease with which a relatively non-opaque calculus may be missed on a dark, heavily exposed film and even a very dense stone on a weak, underexposed film. Time does not permit the retaking of poor films at operation and satisfactory films must be obtained at the first exposure); (g) more accurate localization of stones (in the past it has been disconcerting to the operating surgeon to have the radiologist demonstrate a stone on a film which the most painstaking probing or dissection of a kidney failed to reveal. Much kidney function has been sacrificed, at times the kidney has been removed, and the shock of the operation greatly increased as a result of the mutilation of a kidney containing such a stone or stones. All of these stones can be removed if located, and the new method should permit a more precise localization toward this end); (h) easy identification of artifacts and similar shadows (often local kidney films show confusing shadows which may simulate stones and at times the skill of the radiologist may be taxed to the utmost in establishing their identity); (i) simpleness of construction in attaining these ends.

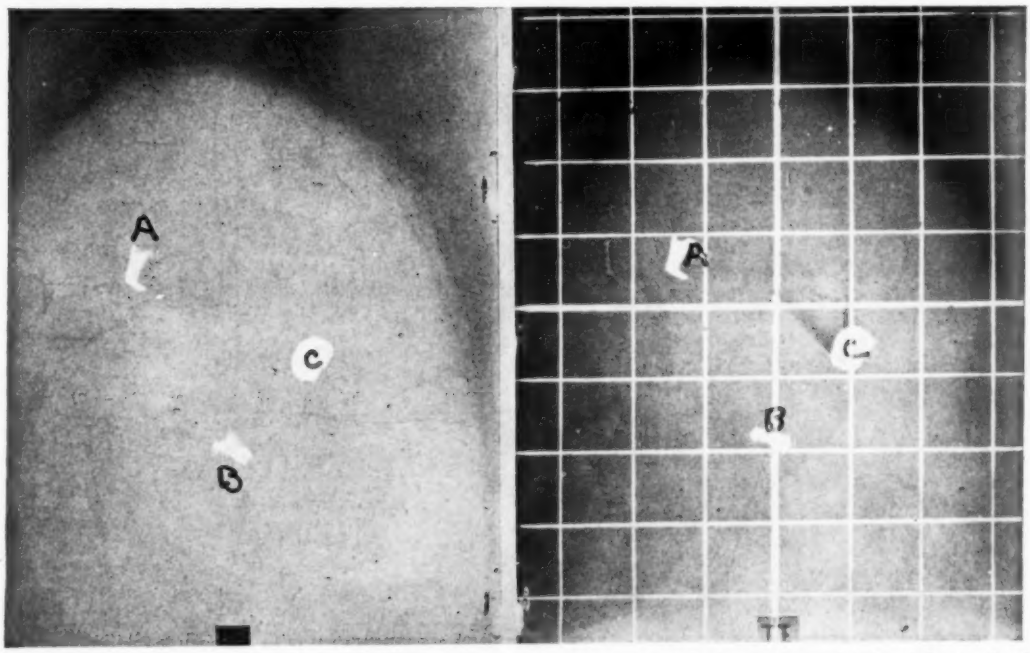


Fig. 2. Localization of improvised stone imbedded in model. Two local kidney films obtained from single *x*-ray exposure show two surface markers (A and B) and stone (C). Second film localizes all three in respect to centimeter pattern of fluorescent screen. After these films were obtained metal centimeter grating localizer was placed over wax kidney in such a position that two surface markers bore same relationships to centimeter localizer that is noted on centimeter patterns of film. Position of calculus was then determined, centimeter localizer being used as a guide. This position was marked on surface of kidney, localizer removed, and on drilling vertically downward with a small drill at this point, foreign body or calculus was recovered without difficulty.

A cassette to meet these requirements has been constructed in the following manner: A rectangular piece of aluminum 0.5 mm. thick, 10.8 cm. wide, and approximately 18 cm. long is bent to the form shown in Figure 1. Its sides are parallel and when folded in this fashion it makes a curved cassette measuring 10.8 cm. in length, 8.5 cm. in width, and 7 mm. in thickness. At the overlapping seam the

two pieces of aluminum are held by two rivets and the seam filled in with "plastic wood." One of the open ends is next filled in with this adhesive wood and when hardened the cassette is ready for use. This forms a slightly curved pocket with an open end, the inside dimensions of which are approximately 10.5 × 8.0 × 0.5 cm. Through the open end is placed a film pack which is composed of two films and one screen wrapped in black paper, the screen being placed between the two films in order to obtain a light and a heavily exposed film. To provide good contact for the screen a thin layer of sponge rubber is cut off the surface of an ordinary rubber bath sponge. The film pack and compression rubber are placed within the folded piece of film base in order to permit it to slip without difficulty into the pocket. This film base which has been cut the same width of the cassette is about 2 cm. longer than twice the length of the cassette. This leaves one end to project 2 cm. out of the cassette which aids in extracting the pack from the pocket after the exposure. During the exposure this free end is folded back into the pocket to be out of the way.

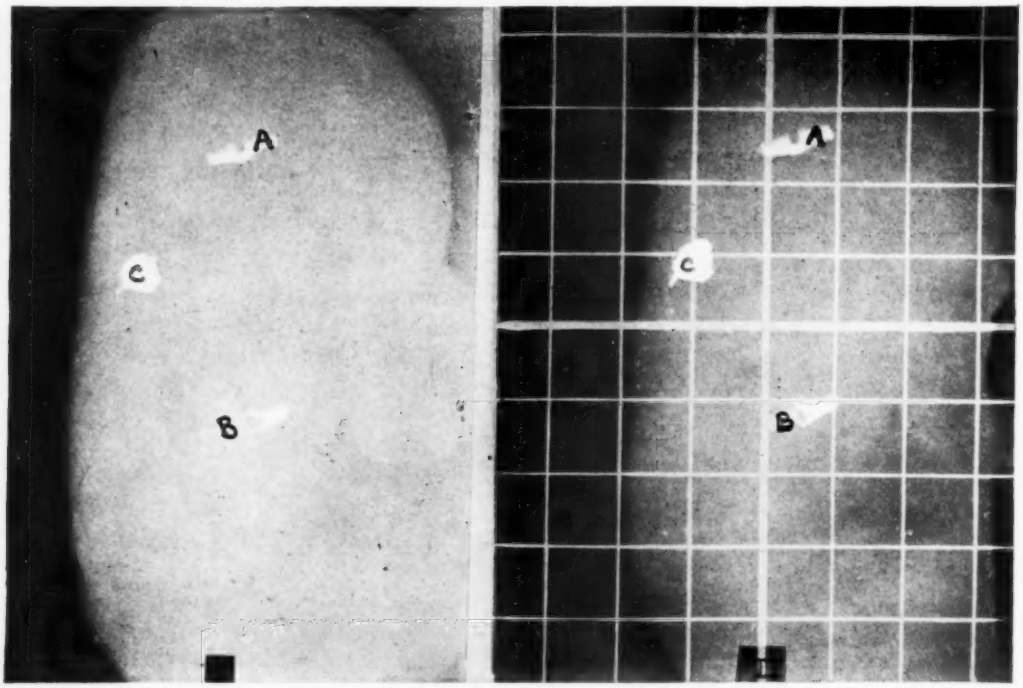


Fig. 3. Localization of improvised stone placed in human kidney obtained at autopsy. Markers (A and B) were placed on surface of kidney after inserting opaque body (C). Films show relationships of these markers to centimeter pattern of fluorescent screen. On placing centimeter grating localizer over kidney so as to maintain these same relationships, location of "calculus" beneath kidney surface is readily determined. This point was marked by placing a needle a short distance in parenchyma of kidney and under fluoroscope by directing needle vertically downward, point of needle was found to come in direct contact with "calculus."

Two notches cut in the concave (front or tube) side of the cassette at the open end will cast shadows on the film and aid in orienting the film after development, i.e. in preventing confusion of the upper with the lower end of film.

The description of the cassette is now complete except for the screen. The screen which has been cut down to proper film size (8.0 × 10.5 cm.) is ruled off with india ink into centimeter or half-inch squares. The middle lines in both planes are made slightly heavier than the others to aid orientation. Since this grating is ruled off on the sensitive side of the fluorescent screen, this same pattern will be noted on the film adjacent to it.

A metal grating of dimensions similar to those of the fluorescent screen is next prepared of suitable wire (Fig. 1). The square pattern of this grating is identical with that of the screen. This grating localizer can be sterilized readily and forms part of the sterile equipment of the operating table. The manner in which it is used at operation will be given later.

The cassette is slipped into a sterile rubber envelop with the open end of the cassette corresponding with the open end of the envelop. If the open end of the envelop was placed during the exposure toward the upper pole of the kidney, the film after development will be held with the two notches uppermost for viewing by the surgeon. The rubber envelop is about 7 cm. longer than the cassette. This end is folded back on itself once and is then rolled and held by any suitable clamp or the hand of the operator.

The *x*-ray beam passes through the following successive layers during exposure: concave aluminum plate, layer of film base, black paper, first film (direct exposure film not affected by screen), fluorescent screen with sensitive side away from tube side of cassette, second film (to be intensified by screen), black paper, compression rubber, layer of film base, convex plate of aluminum cassette.

The procedure at operation is simple. Two metallic markers are placed on the exposed side of the kidney about 3 or 4 cm. apart. They may be placed in any convenient position. The loaded cassette (closed end first) is placed in the sterile rubber bag by means of forceps, avoiding contamination of the outside of the bag. The end is folded and rolled as described. The cassette is slipped beneath the kidney. The *x*-ray tube is directly centered over the kidney avoiding the use of the periphery of the beam, and a film is taken at 26 inches (our operating limit for distance). The concave side of the cassette is toward the *x*-ray tube.

This single exposure yields two films, a lightly exposed film which is excellent for the identification of small or relatively non-opaque stones and a darker, more heavily exposed film which will show the centimeter grating of the fluorescent screen in addition to two opaque identification markers and one or more calculi.

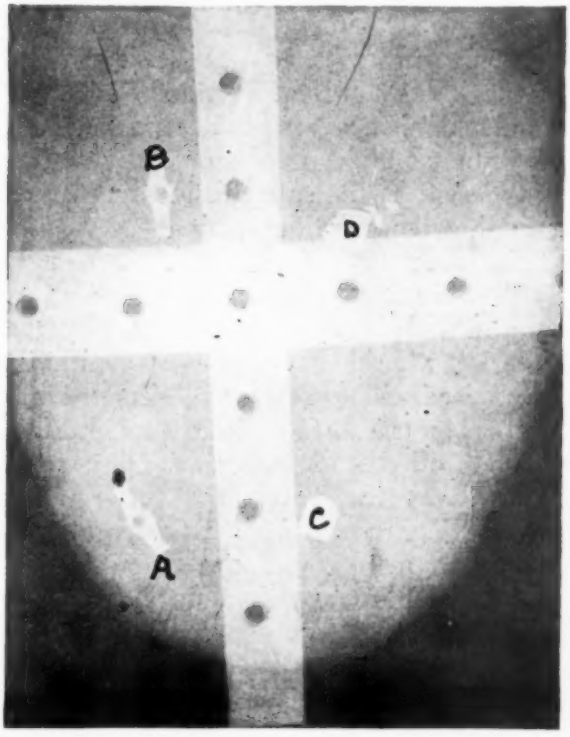


Fig. 4. Test film to determine extent that distortion plays in preventing correct localization. Wax kidney was placed on cassette and two holes (C and D) drilled vertically downward through kidney. Round lead markers were placed over openings on under side of kidney and similar square markers over openings on upper side. A film of such a kidney should show the two sets of markers superimposed if distortion is absent or minimal. Actual result obtained is shown in this illustration. It will be noted that these two sets of markers superimpose over most of their areas. This would indicate that regardless of distance which calculus may be from film, correct localization can be established. Maximal distortion obtainable with wax kidney of average size was determined by placing a brass rule with perforations exactly ½ inch apart longitudinally and transversely across top of kidney. When distance between perforations is measured on film, increase (due to distortion) is only 1/64 inch. This amount in operative practice is negligible.

The calculus is now localized on the film without difficulty by establishing its relations to the centimeter grating of the film. While holding the film for the operator for

this purpose, the film should be held with the correct end up, using the notches as the guide for orientation. The sterile, metallic grating is now oriented over the surface of the exposed kidney, the identification markers being used as a guide. The point on the kidney surface beneath which the calculus lies is now readily determined from the kidney film. A needle or other marker may be left to indicate this location before removing the metallic grating.

The accuracy of this method can be readily checked. A kidney modelled of paraffin was prepared and calculi or opaque material placed at random within the improvised kidney. After placing the two markers on the surface, films were obtained which localized these shadows. The paraffin kidney was then bored at those points indicated by the grating localizer, and these bodies recovered without difficulty. The results are illustrated in Figure 2.

Similar work was done with a human kidney obtained post mortem. The "calculus" was readily identified and oriented in regard to the centimeter pattern of the fluorescent screen (Fig. 3). When the grating localizer was correctly placed over the surface of the kidney, the "calculus" was located accurately and recovered.

It became apparent that the amount of distortion produced by the divergent *x*-ray beam was not sufficient to vitiate results at the distance used (26 cm.). It is important, however, to center the beam over the film, the periphery of the beam being avoided, and to place the cassette at a right angle to the axis of the *x*-ray beam.

To determine the amount of distortion produced when these requirements are met, the following experiment was carried out with the improvised wax kidney: The kidney was placed in the same position as for exposure of a film, and two holes were drilled vertically downward (perpendicular to the cassette) through the entire thickness of the kidney. Two small, square pieces of lead foil were placed over the uppermost termination of the drill holes, and two small, round pieces of foil over the lower end of these same holes. The shadows of these round and square markers should exactly superimpose on a film if distortion is absent. Films (Fig. 4) show the actual result obtained. The shadows of the square markers (farthest from film) are thrown very slightly away from the center, but the amount is so slight that the two sets of shadows superimpose over most of their area. This would appear to be sufficient.

After a more prolonged clinical use of this cassette, a report of actual operative results is contemplated. It may not be amiss to add a word of caution concerning extensive manipulation and probing of the kidney during the development of the film. Such manipulation should be avoided because of the danger of dislodging the stone to a new position. This method of locating stones should be particularly valuable in those cases where (a) the stone has become walled off from the tip of the calyx by connective tissue, and therefore cannot be reached by simple probing methods through the kidney pelvis, (b) stones imbedded in the parenchyma of the kidney, (c) all cases regardless of location of stones in which simple operative procedures fail to locate the stone, (d) all cases of multiple stones in determining their complete removal.

SUMMARY AND CONCLUSIONS

A simple, local, kidney cassette[3] has been described, which is not complicated in construction and can be made in any small laboratory at a trifling cost. Its construction does away with hinges, clasps and special light proofing. It assures proper exposure through the use of two films, one of which is affected by a fluorescent screen. Artifacts produced by films or screen are readily identified because a second film is always obtained and can be used as a control. Using the grating pattern present on one of the two developed films as a guide, the stone can be localized with greater accuracy.

[3] This cassette was designed at the suggestion of Dr. W. W. Scott for use on the Urological Service at the Strong Memorial Hospital. We desire to express our thanks to the Department of Pathology, particularly to Dr. W. B. Hawkins, for supplying us with fresh autopsy material for this work.

NEW INSTRUMENTS

METROPOLITAN HOSPITAL SPONGE-HOLDER*

F. M. Al-Akl, M.D.

NEW YORK CITY

THE object of devising this form of sponge-forceps is the obviation of certain difficulties encountered when using ordinary sponge-holders in preparing the skin of the abdominal wall for operation.

In preparing the abdomen, be it with iodine, picric acid or any of the other antiseptic solutions, the germicidal fluid is first allowed to trickle into the umbilical depression, then after the operative field has been painted, the umbilicus is mopped and the sponge discarded. To have the solution drip into the umbilical fossa one of two things is usually done. The thoroughly impregnated sponge is either carried instantly from the iodine glass and held over the umbilicus, allowing the excess of fluid to trickle into the umbilical depression, or the solution is squeezed out by crushing the sponge between the surgeons' fingers. Both forms of technique are very inadequate. In the former procedure the solution is sprinkled over the hand of the nurse holding the glass, the operating room floor, the surgeon's shoes or gown and the operating table sheets; furthermore the amount of solution falling may not be enough to guarantee a thorough disinfection of the many rugae and fossae of the umbilicus. In the latter procedure, the gloved hand is soiled which, handling the peritoneum later, may irritate the serous membrane.

The forceps in question holds the sponge gently but firmly by means of the six prongs. The impregnated sponge, once over the umbilicus, is crushed. The solution flows as freely as is desired by the compressing action of the two broad plates. The field is painted, then with the sponge in the umbilical fossa, the compression is released and the excess of solution reabsorbed by the decompressed sponge. Thus the sheets and floor of the operating room remain spotless, the umbilicus is thoroughly disinfected, the surgeon's gloves remain clean and non-irritating and the entire procedure is neater.

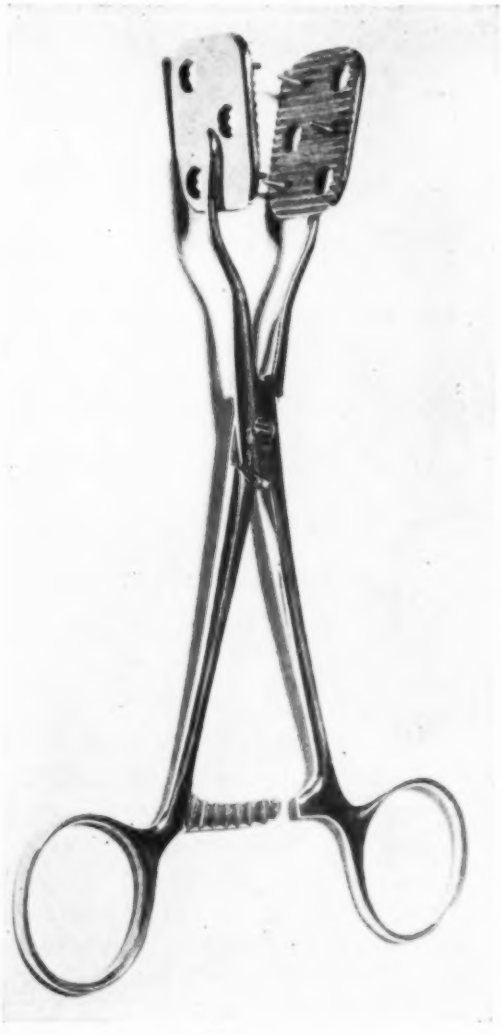


FIG. 1.

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EDITORIALS

PATHOLOGICAL CONSTITUTIONS

THEIR IMPORTANCE FOR SURGERY

TWO factors are usually considered in progress of surgical lesions and indications or contraindications for surgical procedures: (1) local conditions, such as enlargement of the involved organ, pain, tenderness, functional disturbances; (2) general conditions, viz.: age, respiration, temperature, blood count, blood pressure, urine examination, etc. and also the presence of concomitant conditions in remote organs, such as diabetes, tuberculosis, arteriosclerosis, hyperthyroidism, etc. The fact is frequently overlooked that the prognosis depends to a great extent also upon constitutional factors. For purpose of illustration let us take two apparently identical cases of appendicitis where the age of the patient, clinical symptoms, results of laboratory examinations and also operative findings resemble each other; one patient makes an uneventful recovery; the second one dies and the autopsy reveals status thymicus.

It is evident that constitutional pathology is of great importance in the practice of surgery as it may offer warning signs, which if disregarded may lead to a catastrophe. Consideration of individuality of patients is of importance for evaluation of the mode of action of surgical interference. Recognition of constitutional pathology is desirable not only because

it may help to establish a contraindication for an operation but also because some constitutional disturbances may be influenced therapeutically and thus better surgical risks may be created. It is true that constitution is predetermined by germinative cells but somatic fate of the individual may to a certain extent be influenced by extrinsic factors during fetal or postnatal life, e.g. interference with placental circulation, adaptation to climate, exercise, food, etc.

For obvious reasons hypersthenic, athletic types interest the surgeon less than hyposthenic or asthenic conditions caused by hypoplasia or qualitative inferiority of various tissues and organs. Hypoplasia comprises the following conditions: habitus asthenicus, enteroptoticus, neuroticus, phthisicus, thymicolymphathicus, hemasthenicus, etc.

Status thymicolymphaticus is the most important one from the surgical viewpoint. Some authors subdivide it into status thymicus and status lymphaticus, the latter being more frequent, but for our purposes this classification is superfluous. Recognition of such constitutional pathology at autopsy is easier than in vivo but certain signs are suggestive of a status lymphaticus. The head is rather small. The posture is relaxed, muscles poorly developed, chest flat and narrow, ribs have a steep direction, the epigastric angle is sharp, the abdomen flabby. Elasticity of skin is diminished. Lymphatic glands can be palpated on the neck, in the axillae, inguinal regions and other places; the lymph follicles on the base of the tongue are markedly enlarged; this is a very characteristic sign. Hypoplasia of genital organs, asthenic flat foot, varicose veins, varicocele, hemorrhoids, and formation of ganglia in the carpal region are frequently found. The blood pressure is usually low. Blood examination reveals the presence of lymphocytosis. Lability of the nervous system is usually found and psychoneurotic stigmata can be easily detected. Disturbances of the vegetative nervous system in such hypoplastic types manifest themselves in the form of dermographism, profuse perspiration, dilatation of pupils after adrenalin, etc. Roentgenological examination reveals a small heart, enteroptosis, abnormally long presence of epiphyses; persistent or hyperplastic thymus may also be found. During operation, the so-called Bartel's additional symptoms of hypoplasia may be found; état mamelonné of the stomach, long appendix, tortuous tubes. In the history of the patient frequent recurrences of tonsillitis or repeated infections of nasal sinuses or middle ear may be found: not infrequently there is an inclination to skin diseases.

Recognition of such types is important for two reasons: (1) Persistent thymus may be responsible for pathetic death after such trivial surgical procedures as tonsillectomy, circumcision, intravenous injections of salvarsan or other drugs. (2) Such types show an inclination to hyperplasia of connective tissue; adhesions form easily after laparotomies or operations on joints such as arthroplasty. Keloids may form in scars, causing unpleasant disfigurement after thyroidectomies; formation of keloids is especially embarrassing if an operation has been performed for cosmetic reasons. Such fibroplastic potencies are responsible for quantitative overproduction which compensates for poor quality of connective tissue or lack of restitution. Polyserositis observed after abdominal operations on hypoplastic individuals may be caused by inferiority of the lining cells of the serosa, increased production of fibrin or excessive formation of connective tissue in the subepithelial layer. In such cases French authors speak of fibroplastic or fibrous diathesis.

It may be said *cum grano salis* that the hypoplastic constitution offers certain advantages; increased inclination to formation of connective tissue results in facilitated encapsulation after local infections; hence perforations of the appendix, gall bladder or stomach lead to rapid formation

of adhesions preventing the spreading of infection. So-called covered perforations result; furthermore, the hyperplastic lymphatic apparatus serves as a mechanical filter interfering with dissemination of pathogenic microorganisms.

If stigmata of lymphatic constitution are found, a search for persistent or hyperplastic thymus gland is justified. Permanent or intermittent dyspnea may be caused by an enlarged thymus gland; the dyspnea usually has the form of inspiratory stridor. Sometimes percussion may detect the presence of an enlarged thymus. In doubtful cases a radiogram should be made.

If a persistent or enlarged thymus gland is found, an irradiation of this region preliminary to operation is advisable. If the surgical procedure can be postponed, an attempt should be made to raise the resistance of the body by outdoor life, gymnastic exercises and regulation of the diet. If an operation for cosmetic reasons in a hypoplastic individual is contemplated or an operation is planned for other reasons but the cosmetic result is important, as is the case in thyroidectomy, a small incision should be made on the thigh or some other covered place two weeks before the operation; thus an inclination to keloid formation may be detected. Although a keloid may form in one place and not in another, the aspect of the scar may serve as an indicator of fibroplastic tendencies of the organism. Inspection of vaccination scars or scars after previous operations is also of importance for evaluation of fibrous diathesis. As to the prophylactic treatment, hormones, especially extracts of the thyroid gland, have been applied hypodermically and also locally to the wounds. Other authors recommend foreign body therapy. Such prophylactic measures are of highly problematic value. Various methods of dealing with postoperative adhesions have been suggested, e.g. applications of pepsin with or without hydrochloric acid; amniotic fluid; olive oil, camphor oil, etc. Apparently no efficient method is available for prevention or treatment of intraperitoneal adhesions as the authors of all the methods suggested overlooked the fact that in the majority of cases the tendency to form adhesions is due to constitutional and not to local factors.

For hemasthenic types abnormally thin vessels and deficient contractility of the walls of the vessels is characteristic; such factors probably play a role in hemophilia in addition to a disturbance of the chemical composition of the blood. The constitutional inferiority of hemasthenic individuals involves the entire vascular apparatus and probably also the reticuloendothelial system. X-ray irradiation of the spleen before operation in such persons is followed by beneficial results.

A complete physical examination of patients before operations should include examination of lymph follicles of the tongue; lymphocytosis should also attract attention. Positive findings suggest a further search for stigmata of lymphatic constitution. If such are found, a radiogram of the region of the thymus gland should be made. If a persistent or hyperplastic thymus is present, it should be irradiated before any surgical procedure. Thymic hyperplasia with or without objective symptoms is potentially dangerous to life. If patients with status thymicolymphaticus are operated on, special care must be taken to avoid traumatism; tissues should be handled gently in order to avoid the formation of adhesions. This applies chiefly to laparotomies and operations on joints.

Joseph K. Narat

CORRESPONDENCE

OXYGEN LACK IN HYDRAULIC VICIOUS CIRCLE

To The Editor:

In The American Journal of Surgery, June, 1932, in "Hydraulic Vicious Circle as it Develops in Acute Appendicitis," I describe the deoxygenation which is present in hydraulic vicious circle and how it causes infection.

The obstructed appendix fills with fluid. Hydraulic pressure arrests the circulation. Arrested circulation means edema, effusion, more fluid in the appendix, more pressure, more effusion, hydraulic vicious circle.

Oxygen is quickly dissipated from an arrested blood stream. Leucocytes and tissue cells need oxygen for their very life. Practically all the pus-producing bacteria normally present in the appendix grow anaerobically and a perfect anaerobic culture tube is thus provided for them. They promptly multiply; the asphyxiated tissues succumb and an acute infection results, being favored by the dilating influence of the distention and by the increasing stasis of the blood stream.

The correllary of these mechanics is: There will be no infection so long as normally functioning capillaries furnish an adequate supply of oxygen.

I referred to the oxygen determinations of Burget and am pleased to add at this time those of Visscher. I hope some one will make some determinations in acute appendicitis and in abscess.

Dr. Maurice B. Visscher, in charge of the Department of Physiology in the College of Medicine, University of Illinois, Chicago, writes to me under date June 23, 1932, as follows:

My Dear Doctor: I want to report some observations which I have made on the oxygen tension in a loop of intestine in the anesthetized dog. Ringer's solution was introduced into a loop of gut under a pressure of 100 mm. of Hg. Originally a Ringer's solution was equilibrated with oxygen at 140 mm. of Hg. tension. In one-half hour in dog number 1 the oxygen tension had fallen to 60 mm. Hg. The following table gives the results in four dogs:

OXYGEN TENSION IN INTESTINAL LOOP (MM. HG)

	Beginning	Half Hour	One Hour
No. 1	140	60	
No. 2	140	28	12
No. 3	140	28	20
No. 4	140	15	4

Several other experiments yielded identical results. I think it is safe to say that the oxygen in the fluid in the loop of gut under pressure, so great as to stop the flow of blood through the loop, diminishes to practically zero in an hour after the pressure is established.

I feel quite sure that these results will be of interest to you, because I believe they confirm very directly your views as to the rapidity with which a tissue deprived of its blood supply uses up all of its oxygen.

I believe that my description in the above-named article is the first mention of this factor in infection. At least I can find no previous record of it, and my discussion with several well-known bacteriologists confirms that opinion.

C. Van Zwalenburg.

JOSEPH LOVELL

JOSEPH LOVELL was born in Boston, December 22, 1788. He graduated from Harvard in 1807, studied medicine under Dr. Ingalls of Boston, and graduated from Harvard Medical School in 1811.

The year after his graduation Lovell entered the Army, as surgeon of the Ninth Infantry. During the greater part of the War of 1812 he was in charge of the General Hospital at Burlington, Vermont, where, in 1814, he became Hospital Surgeon.

Following the War of 1812 the medical department of the Army was formally organized, and in 1818 Lovell was appointed Surgeon-General. He lost no time in making sweeping changes and organizing his department. He revised and reissued the regulations for its government. In 1821 he further improved and elaborated the organization. The form of organization which Lovell finally perfected continued in force until 1861. In 1834 he inaugurated a system of examinations for admission to the medical corps, which system of examination has continued to the present time.

In Packard's "History of Medicine in the United States"[1] we read: "Alcoholism was rife and a cause of much sickness. Surgeon-General Lovell, who was a strong advocate of temperance and whose labors and reports eventually resulted in the abolition of the rum ration, possibly unconsciously exaggerated the harm resulting from drink, but he ascribed more than half of the deaths in the Army during the decade 1819–1828, to 'this war against nature.'"

Lovell administered the affairs of the medical department in the early part of the Seminole War.

Among other worthy works an outstanding one was Lovell's encouragement of and assistance to Dr. William Beaumont, whose work on gastric digestion resulting from his observations upon Alexis St. Martin is one of the classical sagas of American medicine.

We read of Lovell that "In all his relations, whether as Christian philanthropist, profound scholar, skillful surgeon, experienced officer or true hearted gentleman, he was one of whom the Medical Staff may always be proud."

Joseph Lovell died October 17, 1836.

T. S. W.

[1] N. Y., Hoeber, 1931.

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JOSEPH LOVELL

[1788-1836]

The American Journal of Surgery
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[From Fernelius' Universa Medicina, Geneva, 1679.]

BOOKSHELF BROWSING

THE ROLE OF EXPERIMENTS ON ANIMALS IN THE TREATMENT OF DISEASE*

MODERN SURGERY

A. STEPHENS GRAHAM, M.D.

ROCHESTER, MINNESOTA

INTRODUCTION

THE surgeon of today is capable of operating, with a relatively high degree of success and a remarkably low mortality rate on almost all parts of the human body. Operations include those on the brain, spine, stomach, liver, gallbladder, appendix, pancreas, spleen, kidneys, arteries, veins, and nerves. Furthermore, such operations, with but few exceptions, owe their origin, as well as their success, to animal experimentation.

In fact, modern progressive surgery, as developed from animal experimentation, represents strikingly a marked deviation from the deeply worn and uncertain paths of empiricism. Empiricism as used here implies a principle of treatment devoid of experimentation and based on an application of logic to facts born of observation, in instances in which the observations are too often superficial and the logic unsound. "The art of observation," says Dumas in a letter to Pasteur, "and that of experimentation are very distinct. In the first case, the fact may either proceed from logical reasoning or be mere good fortune; it is sufficient to have some penetration and the sense of truth in order to profit by it. But the art of experimentation leads from the first to the last link of the chain, without hesitation and without a blank, making successive use of Reason, which suggests an alternative, and of Experience, which decides on it, until starting from a faint glimmer, the full blaze of light is reached."

At about the middle of the nineteenth century anesthesia made its timely appearance as the first vital factor in the development of modern surgery. Anticipated and sought for since the beginning of surgery, it was but natural that the use of anesthetics should at once become almost universal. Operations that had been impossible could now be performed; for the most part these operations were in the abdomen and were first performed and perfected on animals. The technique of some of these operations approached perfection, and even today is used with little or no change, and yet the procedures were soon discarded, because of the havoc wrought by infection in the abdomen and in the wounds incident to the opera-

* This is the sixth of a series of articles on the value of animal experimentation in medical progress. The next article will appear in an early issue. This paper was prepared for publication in a lay journal.

tion. The mortality following these early operations was distressingly high, and the pain that had been so mercifully eliminated from the operation by the anesthetic, soon manifested itself in the pus-laden, heavily infected wounds. Yet the surgeons of this early period still spoke of "laudable" pus, and labored in ignorance of the antiseptic method of surgery.

This state, however, did not exist long. Barely a quarter of a century later, Pasteur's researches on fermentation and his epoch-making animal experiments with bacteria were applied by the surgeon Lister in the building of an antiseptic method of surgical procedure. The "full blaze of light" is not yet reached; but through constant experimentation and the application of its results to repair of the human body, the glow of perfection becomes brighter.

Since the very earliest times the surgeon has been first the anatomist, second the operator and third the pathologist. He has dissected human bodies when possible; but in the early centuries this was frequently difficult because of the superstition and ignorance which clogged the wheels of progress. Where such conditions prevailed the surgeon resorted to animal dissection in order to glean knowledge applicable to human beings. As a pathologist he became interested in the investigation of the dead, in the hope that by determining the effects of disease some method of cure might be discovered. Gradually pathology grew into a great independent science, which exerted and still exerts a powerful and stimulating influence on surgery. The animal experiments of the great German pathologist Virchow (1821–1902) play no small part in this rapid growth.

The surgeon became interested in bacteriology when the antiseptic method was introduced into surgery, and he has maintained that interest ever since although he leaves its progress and its interpretation to the skilled bacteriologist. In more recent years the important influence of physiology has appeared, to remove the mantle of secrecy from nearly every organ in the body and to demonstrate the various functions by animal experimentation. Operations today must be more than merely technically perfect; they must meet all the exacting requirements of physiology. Nor can the average surgeon in a consideration of the broad scope of this fundamental science hope to master all of its intricate details; he must be guided by those who make this their life work. Thus has surgery emerged from the baleful darkness of ignorance and uncertain empiricism, into a scientific art of sure beneficence, closely associated with, and ever influenced by, these basic sciences.

It is fitting to state here that modern surgical experiments on animals are conducted with the same careful consideration that is shown by the surgeon in the care of his patients. Complete surgical anesthesia is invariably maintained to forestall the possibility of pain and discomfort; and conditions of strict antisepsis are adhered to in all operations. Particular attention is paid to the care of the animals after operation; their quarters are hygienic and comfortable, and their diets are carefully adjusted to individual needs. In fact, in order that the experimental observations may be entirely applicable to the treatment of diseases of man, they must be made under conditions closely analogous to those of the human patient.

SURGERY OF THE ABDOMEN

The abdomen was appropriately named from the Latin verb meaning to hide. For a period of more than a thousand years, from the beginning of surgery to about 1875, this important cavity of the body has managed well to withhold its secrets from the surgeon. The manner in which this veil of secrecy was finally lifted through the combined agencies of anesthesia and antisepsis has been related. It might well be asked, however, if surgeons in the early days could operate on blood vessels in

order to "bleed" a patient, and make holes in the skull, trephine, to relieve increased pressure within the head, and amputate limbs, all without anesthetics, why he could not likewise operate on the abdomen and its contents. The answer is simple: Any one of the foregoing operations could be consummated with extreme rapidity, often within a few minutes, whereas abdominal operations required considerably more time and more exactness. The pain incident to such a long procedure would be almost unbearable and conducive to fatal shock. Furthermore, the violent movements of the stomach and intestine in the absence of an anesthetic would alone make the operation practically impossible.

The rôle of animal experimentation in the actual development of abdominal surgery is a story of brilliant ingeniousness and of infinite humaneness. Every basic principle essential to operations in the abdomen, and almost every subsequent new procedure, was first carefully tested on animals. Such procedures were so entirely new as to have barely a single precedent, even as related to fundamental principles, by which the surgeon could be guided. There was practically no parallel between the meager surgical procedures on the skull, the blood vessels, and the extremities, and those he was about to carry out on the various abdominal organs. There were many pertinent questions of a basic nature that needed immediate answer such as: Could an opening be made into the stomach or the intestine, or a piece of either be removed, and the edges then be brought together and sewed, and if so what material would best serve the purpose for sewing; silk, linen, cotton, or "catgut"? Could the entire stomach or a large portion of the intestine be removed? These and many other questions were promptly answered by numerous carefully conducted experiments on animals, and the fact that the investigators were for the most part among the leading surgeons of the day did much to hasten the universal acceptance and practical application of their observations on animals.

The year 1875 marks the beginning of new surgery of the digestive tract, the stomach and the intestines. Experiments on animals performed in that year and the succeeding year had far-reaching effects on surgery as applied to human beings; they initiated a vigorous continuous wave of progress. In the first year Tschertneisky-Barischewsky cut out pieces of intestine in thirty-five dogs; twenty-nine recovered, a most inspiring accomplishment. In the next year Gussenbauer and Winiwarter removed portions of the stomach in a series of dogs, and examined the stomachs of those that lived several months later. These experiments are of historic significance and of fundamental importance. They demonstrated that the raw edges of the cut stomach were not attacked by the digestive juices of this organ, that certain materials were best suited for stitching the cut edges together, that contraction or distortion of the stomach did not occur at the site of the operative scar, and that the pylorus could be removed, along with a considerable portion of the stomach proper, without any ill effects on the processes of digestion. The last observation was destined to play a vital part in the strenuous campaign that was soon to be inaugurated against cancer of the stomach. But in the meanwhile considerable interest was manifested in the simpler operations on the intestines.

Hueter, in 1876, operated on and sewed up the intestine in man, although without success. He was soon followed by Czerny and the great surgeon Billroth, both successful in removing portions of the intestines and reuniting their severed ends. The results of these experiments and subsequent first trials on man quickly spread to all parts of the world. Surgeons in every country performed such operations and promptly reported their failures and their successes. Other experiments were immediately begun with a view to bettering the technic of joining the severed

portions of the digestive tract in order to prevent fatal leakage. The experiments were carried on in this country chiefly by Senn, Abbe, Brockaw, Ashton and Murphy. Senn, besides improving the technic of uniting the ends of the bowel which had been cut, contributed valuable information concerning the rapidly fatal condition of intestinal obstruction. He produced experimental obstructions in the bowel of animals comparable to those in man, and demonstrated how these could be removed and in case of cancer or gangrene the manner in which the diseased bowel itself could be best removed.

In this early period cancer of the stomach, more than any other one disease, occupied the surgeon's careful consideration. The toll from this disease was appalling and the manner in which the patient died was pitiful. Usually there were months of suffering accompanied by gradual starvation. The cancer usually commenced near the outlet of the stomach, and slowly encircled it so that by degrees the pylorus became obstructed until eventually no food could pass out of the stomach. Pean in 1879, following the experimental procedure of Winiwarter, removed the pylorus for the first time in man; the cancer was far advanced and the patient died shortly afterward. Billroth a year later performed the third operation, the first successful one, which necessitated removal of about a third of the stomach, and then reconnected it to the intestine. Since then, there have been hundreds of such operations successfully performed, not alone for the removal of cancer, but in recent years for the removal of ulcers of the stomach and the duodenum. Since many patients, however, fail to reach the surgeon before the disease has already spread throughout the body, surgery in these cases can be no more than palliative.

Sometimes the cancer is in the esophagus or in the cardiac end of the stomach, and in either case it prevents nourishment from entering the digestive tract. As early as 1837 an opening through the abdomen into the stomach was suggested as a means of feeding these patients. The operation of gastrostomy was first performed by Sédillot in 1849 and again by him four years later; unfortunately both operations terminated fatally. He was severely criticised by the profession and the public for his boldness; he had not first tested and perfected the operation on animals. During the next quarter of a century twenty-seven similar operations were attempted with twenty-seven failures. It is true that the lack of an antiseptic method of performing operations was in part responsible for this high mortality, but most important was the lack of a fundamental knowledge of surgery. The mortality remained high, even after the introduction of antisepsis, until 1890, when the first thoroughly scientific operation of this nature was perfected on animals. From then on there has been a constant lessening of the mortality to the present comparatively low rate.

The method of feeding directly into the stomach is not alone useful in cases of cancer; it has proved a life-saving measure in those pathetic instances, too often seen today, of young children who have swallowed lye or some other corrosive, carelessly left within their reach. The corrosive usually results in stricture of the esophagus that prevents solid food and often even liquid food, from entering the stomach. Immediate establishment of a gastrostomy or enterostomy is demanded and until the stricture has been gradually stretched, often requiring months, all nourishment is supplied through a tube directly into the stomach or intestine.

Another milestone in the splendid progress of abdominal surgery is the advent of modern surgery of the kidney. The manner in which this was brought about represents one of the finest examples of the direct benefits to mankind derived from animal experimentation. Simon, in 1869, was confronted with the proposition of removing an apparently healthy kidney from a healthy woman. Many years before, the

tube leading from one of the kidneys to the bladder was injured, with the result that the ureter had grown into the abdominal wall and urine escaped continuously over her person, a most deplorable condition. Whether man could survive with but one kidney was unknown. There were cases in which one kidney had become gradually destroyed by disease, but in such instances the other kidney slowly became larger and eventually was capable of assuming the work of both. To remove a healthy kidney suddenly was a different matter. It was not even known how the kidney could best be removed since it is situated beneath the intestines and close to the spine. From the results of experiments on a number of dogs, Simon decided that one kidney would suffice and experiments on the cadaver showed the best mode of entrance to be through the loin. He then perfected on dogs the operation for removing the kidney. At last, thoroughly satisfied that he was justified in operating, he removed the kidney that was giving rise to the abdominal discharge and the patient lived in health for eight years. These few experiments opened wide the way to entirely new surgical procedures.

Most of the advances in abdominal surgery so far reported have followed the original investigations on animals by Germans and Austrians; as a result they led the world in surgical progress for years. It is therefore gratifiying to relate the inspiring and humane studies of Parkes and Senn, both Americans who were first to demonstrate by animal experiments the advisability, in fact the duty, of the surgeon to explore the abdomen in cases of gunshot and stab wounds. During the Civil War all such wounds were left essentially to the mercy of Nature, for surgical intervention was considered unjustifiable. In many body wounds and in many diseases Nature plays an important rôle and the surgeon relied on this unseen aid; but in wounds of the stomach and the small intestines she saved barely an average of one patient out of each hundred. Of the sixty-four soldiers who were reported to have sustained wounds of the stomach during the Civil War, only one lived. Of more than 650 who sustained wounds of the intestines only five of those whose wounds were in the small intestine survived, and only fifty-nine of those whose wounds were in the large intestine, a mortality of 90 per cent! Parkes, in 1884, with this in mind, conducted a series of systematic and carefully performed experiments on animals in which the animal was deeply etherized, then a small shot was projected through the abdominal wall, the abdomen opened, and the wounds of the intestines, blood vessels, and other abdominal organs treated by appropriate surgical methods. The results were reassuring and instantaneous in their influence on many surgeons in the treatment of similar cases. The next year Bull successfully repaired seven wounds in the intestines of a man shot with a pistol. Senn carried the experimental study still further and developed a method in animals whereby the perforated bowel could be definitely diagnosed before operation. Since this time there have been hundreds of such wounds successfully treated and recovery has been reported after as many as twenty-two gunshot perforations of the bowel.

It is interesting to compare the respective mortality rates incident to wounds of the abdomen during the Civil War and of those during the World War. In the former there were no abdominal operations recorded and the death rate was more than 90 per cent. In the latter there was a large number of such operations and the mortality was 43.32 per cent. Yet "intra-abdominal wounds in the war just ended," reads the official report of the Medical Department of the World War, "were definitely more grave than in preceding wars because of the nature of the projectiles used." Machine-gun bullets and high-explosive shell fragments in particular were responsible for the frightful wounds inflicted within the abdomen. Colonel Gibson, U.S.A., stated that in nineteen

months of active service overseas he did not come in contact with an incident in which recovery followed an intra-abdominal wound unless operation was resorted to.

Many other abdominal operations have originated through animal experimentation but lack of space will not permit their discussion here. In recent years experimenters have had in mind chiefly the improvement of abdominal operations already in use. The basic principles of operations which originated in the latter part of the nineteenth century still obtain in most instances, but the procedures have been so carefully perfected on animals that the mortality even in the hands of the average operator is remarkably low. Then, too, many surgeons are now trained by first operating on animals, in order that their skill may be developed to a high degree before operations are attempted on man. Even the skilled operator often resorts to animal tests before undertaking an operation that is new to him and which is technically difficult. It is significant that the newly organized National Board of Medical Examiners* requires the applicant for licensure to operate on animals, when these are available, in the presence of an examining board, that it may be determined whether the applicant is thoroughly acquainted with the basic principles underlying abdominal surgery. Requirements such as these tend greatly to raise the surgical standard of perfection and thus further to safeguard the patient whose life is placed in the hands of the surgeon. Indeed, these methods of animal experimentation, and practice in surgical technic, are not only of the utmost practical significance, but what is more, they are vitally humane.

*This Board was organized with the purpose of establishing a standard qualifying examination of such a high character that the certificate awarded successful candidates could be safely accepted by all the State Boards of Medical Licensure as an adequate qualification for the practice of medicine.

SURGERY OF THE CHEST

The surgery of this great cavity, enclosed by the ribs, advanced slowly and cautiously, far behind the brilliant progress in abdominal surgery. This was in part due to the greater complexity of the chest in comparison with the abdomen, and in part to the lack of definite knowledge concerning the physiology of respiration. The biologic aphorism, "no life without breathing," indicates in a general way the importance of respiration. Man may survive for weeks without food and for days without water, but can exist only a few minutes if deprived of air. Naturally the surgeon would meditate long before dealing surgically with a process so vital as respiration. But this was not the sole reason for concern. The heart and its great vessels, so intimately related anatomically to the lungs and the bronchi constituted a grave potential danger in any operation on the chest. Operation on the heart itself was considered no more than a fantastic dream.

Although remedial surgical procedures in the region of the chest were slow in developing, there was urgent need for them. Foremost was the need of removing foreign bodies, either swallowed and lodged in the esophagus, or drawn down the air passages into lungs. Usually these accidents occurred in children and constituted a pitiful group of sufferers. Safety pins, buttons, marbles, pieces of toys and, in fact, almost every small object one can imagine has managed to find its way into the lungs. The ingeniously devised instruments, the bronchoscope and the esophagoscope, which today usually make operation unnecessary in such cases, were not available until comparatively recent years. The perfection of these remarkable procedures depended to a considerable extent on animal experimentation. Then, there were abscesses of the lung, either spontaneous or following pneumonia. Death often claimed the miserable victim. Spontaneous rupture into the bronchi, Nature's method

of ridding the body of the accumulated poison, was the best hope, but Nature was not always benevolently inclined.

Cancer of the esophagus was also badly in need of some means of treatment. Buried behind the lungs, bronchi, and important nerves, and closely attached to the great blood vessels, the esophagus was extremely difficult of access. There was, also, need for an efficient method for repairing wounds of the chest, wounds from all varieties of accidents, from gunshots and from stabs.

Sauerbruch, in 1904, supplied the vigorous impetus so essential to the splendid new surgery of the chest that was destined to make its appearance in the first quarter of the present century. This was in the form of a specially constructed air-tight chamber in which operations could be performed on the chest without hindrance to the processes of breathing; the air in the chamber could be either exhausted or compressed in order to prevent collapse of the lung. The perfection of this unique and highly scientific apparatus was made possible through the availability of the dog as an experimental animal. Willy Meyer modified this chamber and within its confines removed part or all of one lung in twenty-six dogs, with twenty-two recoveries (84 per cent). These tests further inspired the surgeon, lending courage to those who only awaited such a confirmation of Sauerbruch's original and excellent method. Almost immediately there were reports of remarkable operations performed in these chambers, operations by noted surgeons, such as von Eiselsberg and Trendelenburg. Both of these men first developed methods on animals and then applied them to man. But here it is necessary to record the objection to the apparatus. It was available to only a chosen few since it was bulky, stationary and expensive, and consequently it was installed in only a few of the larger universities in this country and on the continent. Still, the knowledge derived from physiologic experiments on animals in the Sauerbruch chamber was of inestimable practical benefit to the surgeon in subsequent years. It was in this manner that he became acquainted with the normal action of the heart and lungs, and their reaction to disease and treatment.

Five years after Sauerbruch's memorable contribution, Meltzer and Auer, of the Rockefeller Institute in experimenting on dogs, provided the much needed simple procedure which could be substituted for the chamber in operations on the chest. It provided for artificial "ventilation of the lungs," produced by the introduction of a small tube into the trachea which would permit a warmed mixture of oxygen and ether to be forced gently through into the lungs. Collapse of the lungs during an operation was thus forestalled and the normal processes of respiration continued without impediment. This was indeed a long stride forward. Immediately, experiments on animals by thoroughly competent surgeons multiplied. Operations were devised for the removal of cancer of the esophagus, for injuries and diseases of the great blood vessels and the heart, for cases of advanced consumption and for other serious conditions. Carrel, of the Rockefeller Institute, who by his remarkable ingenuity and dexterity, has contributed so much to our knowledge of surgery of the blood vessels and the transplantation of organs, was one of the first to utilize the Meltzer-Auer method in operating on the chest of animals. In 1910 he reported a series of experiments in which the thoracic aorta was severed completely and the continuity immediately reëstablished by sewing the cut ends together. Many of these animals survived. This study pointed the way to repair of the large blood vessels of the chest, and suggested other possible operations which time and more experience will undoubtedly prove of value. These methods of repair were used to great advantage in the World War and subsequently in civil practice.

The foregoing relates to fundamental discoveries made on animals and the ready

application of these discoveries to the alleviation of human suffering. The investigators were pioneers, workers in an intricate and little understood field of surgical endeavor. A world calamity was necessary in order to put many of their experiments to a thorough test, to elaborate on them through observations on the maimed, and through further study of animals. The recent official report on surgery of the chest during the World War to the Surgeon General of the United States Army is in reality a vivid description of recent experimental procedures in the cavity of the chest. In France, under the leadership of Brigadier General J. M. T. Finney, a laboratory of Surgical Research was established where many of America's most illustrious scientists, experimental physiologists, pathologists, chemists, experts on anesthesia, and surgeons, concentrated their efforts in the investigation, through animal experiments, of devices and new methods to meet the ever increasing demands. There was no end to problems. In each battle new implements of death were brought into action: the various types of poisonous gas, liquid fire and shrapnel, and always the devastating machine gun fire.

Wounds of the chest were numerous and it was essential that a simple yet highly efficient method be invented for keeping the patient asleep during operation and at the same time preventing the lungs from collapsing. Ether had its disadvantages; so had chloroform; some other anesthetic was needed. Captain Gwathmey started experimenting with nitrous oxide gas. In reading the official report relating to these experiments we find the following interesting evaluation: "Animal experimentation showed clearly that administering anesthesia under tension, particularly when the chest is opened, was dangerous if the gas or ether was given in increased concentration" . . . and "So closely related is the physiology of man and dog,* in spite of the gross anatomical differences in the pleura and mediastinum, that the principles established experimentally were directly applicable to the wounded."* The American Red Cross Nitrous Oxide Apparatus thus perfected by Captain Gwathmey, entirely through animal experimentation, and adopted by the Army, fulfilled every requirement and proved to be of inestimable value to the surgeon operating on the chest.

Now that the anesthesia problem was solved, all efforts were centered on standardizing methods for repairing the thousands of chests mutilated by the instruments of war, which were ever increasing in numbers and in power of destruction. How could the lung best be sewed up after the removal of an injured portion? There was little precedent to follow and then there was lacking a unanimity of opinion as to the best methods. However, thanks to the excellent animal experiments of Willy Meyer, and others, in which measures were devised for removing a portion or all of one lung, a foundation was laid on which further to build our knowledge. But never before was the surgeon confronted with such a variety of severe injuries of the lung as were brought to him at the battle front; lungs rent with bullets, macerated by fragments of exploded shells, and not infrequently, gangrenous in portions due to injury and subsequent delay in treatment. Should he remove the entire lung in these cases of injury? That probably would have often been the line of least resistance; but was there not a way to save most of this vital organ; who knew but what the other lung might some day become diseased? The modern trend of surgery is to conserve every piece of injured tissue that is not definitely proved irreparable. It was said of that venerable master of surgery, the late Dr. Halsted, who wielded such an important influence in the establishment of this conservative trend, that "he stood firm on the ground that the nature of the material upon which the surgeon exercised his handicraft is too noble and too precious to be insulted with impunity or to allow even

the smallest living particle to be wasted." By animal experimentation and clinical application he was ever demonstrating this.

The same problem had confronted earlier surgeons in the face of severe injuries to the arm and leg. Twenty years ago many limbs were amputated which today would be saved in their entirety, or greater part. The problem was solved then as it was solved by these workers in France, relative to injuries of the lung, by animal experimentation. So striking were these earlier experiments that it seems best to digress in order briefly to relate them. Abbe, before the New York Academy of Medicine in 1894 almost amputated a dog's foreleg, leaving the limb connected with the body by nothing but the artery and vein. He wired the bones together, sewed muscles and nerves end-to-end, and placed the leg in a cast of plaster. After four months this almost amputated limb was perfectly united. A few years later, Carrel and Guthrie, of the Rockefeller Institute, went even further. They removed the entire leg of one dog and transplanted the corresponding leg of a second dog to the body of the first one. Here, besides rejoining bone, muscle, and nerve, they had added difficulty of rejoining blood vessels. Yet, the transplanted limb grew firmly to its new stump.

Such experiments as these inspire the surgeon with confidence; they justify an application of the principles involved to operations on human beings. Although limbs have not been transplanted in man, many severely maimed arms and legs have been saved to serve an economic usefulness. The same is true with regard to injuries of the lungs. In the surgical research laboratories, behind the battle lines in France, studies were made of injured lungs in animals to determine to what extent these wounds may be conservatively repaired by simple sutures, without gross amputation of lung tissue.

In time these and other serious difficulties were mastered. Many injured lungs were conservatively treated, as healing was found to be kindly where there was no infection; ingeniously conceived methods for stitching the frail substance of the lung were invented; repair of the injured wall of the chest was studied; experiments were performed to determine whether the surgeon was justified in draining the chest of large accumulations of blood, as would often follow the passage of a single bullet through the chest, yet without inflicting serious injury to its contents. These constitute but a few of the most important problems these splendid investigators set out to solve, but they suffice to show the great value of animal experimentation in the progress of such procedures during the War. It is worthy of note that with these workers the gruesome realities of war dulled not a whit those fine instincts of kindliness, gentleness, and compassion toward the animals that they were compelled to substitute for the maimed soldier, in experimenting. These animals, most of whom were condemned to destruction in the municipal guillotines, were treated with the same consideration as were accorded the injured soldier in the base hospitals. "The dogs were invariably operated on," reads the official report, "in ether or nitrous oxide narcosis, and were protected against unavoidable distress by a free use of morphine before and after operation."

We leave France and the battle field for at home a great scourge, influenza, was ravaging the country; it killed more than did the implements of war. It spread to the remotest village and attacked man, woman and child. In its wake were left thousands maimed in a most miserable fashion by the dread empyema. The army cantonments held large numbers of such patients and in the early days a few survived; but there were still more who died. In March 1918, the Surgeon General of the Army sent questionnaires to each cantonment in order to determine their various methods of treatment of empyema and their respective death rates. The average mortality was 30.2 per cent;

in one locality it was as high as 90 per cent.

What was to be done? These soldiers were dying by the thousands. Were they to be experimented on? Apparently not. But then, what? The Empyema Commission, created by the Government to solve the problem, deliberated; conflicting views as to treatment were presented; the treatment at that time consisted of making an opening in the diseased chest as promptly as the condition was diagnosed, to permit free drainage of the pus. But too many soldiers were dying. Immediately, action was demanded.

The Commission detailed two of its members, Graham and Bell, to solve this urgent problem through animal experimentation. They at once set about to the task of producing experimental empyema and pneumonia in dogs. In one series of cases ten dogs with empyema were operated on; another series of ten was not operated on. From the results of these experiments it was clearly shown that to open the chest early in the face of pneumonia was unwise. Other experiments demonstrated the size of the opening in the wall of the chest that might be compatible with life. Still other experiments covered certain additional controversial points in treatment.

The treatment suggested by these observations on animals was in full accord with the deductions that the Commission had previously made from a study of the accumulated data relative to empyema in the soldier. But the Commission did not feel justified in putting into full action, as mandatory for all the cantonments, the methods of treatment born of these deductions. We now know that the death rate in cases treated in harmony with the results of the experiments of Graham and Bell was reduced to the extremely low rate of 3.4 per cent. Yet before this, an average of thirty soldiers died out of each 100 afflicted with empyema. Is it possible that any one could wish that these experiments had not been performed in order that the animals thus sacrificed on the alter of humane progress in surgery could now live?

It might be well in passing to mention that during the last ten years there have been many other investigators studying the mechanism of the chest and its contents. Some of these have corroborated the observations of Graham and Bell, while others feel that they cannot accept in their entirety their physiologic interpretations. But this does not imply doubt with regard to the inestimable value of their experiments in causing the marked reduction in the death rate in empyema. Snyder, working at the Institute of Experimental Medicine of The Mayo Foundation, performed experiments which led him to maintain a somewhat different viewpoint as to the mechanism of the cavity of the chest. He stated, however: "The opportune work of Graham and Bell was undoubtedly responsible for the saving of many lives during the recent epidemic of influenza."

SURGERY OF THE HEART

It is fitting that discussion of the heart should come at the close of the discussion of thoracic surgery; for it is only within recent years that surgery of the heart has received serious consideration. Although still in its early infancy, recent experimental studies betoken a splendid future for this type of surgery. Allen, of St. Louis, has within the last few years developed a method on dogs whereby the heart can be entered with an ingeniously devised instrument that permits the operator to view the entire inside of the heart during the operation and yet does not allow a drop of blood to be lost.

Heretofore the surgeon was required to operate with extreme swiftness, taking not longer than one or two minutes, and all manipulations inside the heart were of necessity done by the sense of touch alone. There have been comparatively few operations performed on the heart; for there have been few surgeons so bold as to

adventure on this uncharted sea of great potential dangers. But there has been a definite need for this type of operation. There is a large group of sufferers who are condemned to long years of invalidism, or to early death. Such patients have diseased heart valves which become thickened and distorted by disease, or partially destroyed, the valves leak and eventually the heart reaches the limit of its ability to compensate for an ever increasing disability.

In the light of the remarkable reconstructions consummated by the surgeon in nearly every part of the body, it is but natural to expect that the time is not far distant when his skill will be applied toward lengthening the span of life in that large group of persons whose heart valves are diseased. These valves have been operated on in the dog and there will be many repetitions of such operations; eventually all doubt will be dispelled and every weak point in the theory of the procedure will be covered with sound experimental reassurance; then man will profit from these long years of cautious testing and retesting.

BOOK REVIEWS

RECONSTRUCTION OF THE BILIARY TRACT. By Edmund Horgan, M.D. N. Y., Macmillan & Co., 1932.

This is a comprehensive, well-written, and well-illustrated monograph on an important topic. There are few situations more tragic than that of the man or woman who comes with a common duct so scarred that it will no longer carry bile. If something is not done these people must go downhill and die a lingering death. Many procedures have been devised which will return these patients to health, and they are all well described by Dr. Horgan. The reviewer's only regret is that there are so few surgeons skillful and experienced enough to do this type of work; he wishes there were more men in the country interested enough to buy this book and repay the devotion of the writer and the publisher.

ATLAS DER RÖNTGENSTEREOSKOPIE. (Atlas of Roentgenstereoscopy.) By Max Cohn, Physician in Charge of the Roentgen Dept., State Hosp. in Friedrickshain-Berlin. First Series of 20 negative film transparencies, with a folding stereoscope. Leipzig, Georg Thieme, 1932.

This is a laudable attempt to bring to the medical public education in what roentgenology can accomplish toward clearing up obscure diagnoses. The twenty films chosen for the first series have been happily selected to exemplify the value of the roentgen diagnosis, and especially of the stereoscopic method as applied to this diagnostic work. Aside from cinematography, there is nothing in the way of photographic teaching methods to compare with the use of stereograms. It will be interesting to see what the future brings forth in this venture. Among the interesting cases presented are included ectopia of the kidney due to retroperitoneal lipoma; perforation of a tuberculous kidney; demonstration of the duodenum by the method of Pribram; echinococcus of the lung; fracture-dislocation of the lumbar spine, with myelography to demonstrate compression of the spinal canal at the site of the fracture; cysticerci of the muscles of the thigh and pelvis.

DIATETIK BEI CHIRURGISCHEN ERKRANKUNGEN. (Diet in Surgical Disease.) By F. W. Lapp and H. Neuffer. Berlin, Julius Springer, 1932.

There is no question about the desirability of better dietetic care of patients who have submitted to operation. Just at present, with most of the dietitians worried sick over vitamins, about all the average patient, recovering from a gastric or intestinal operation, can get in an American hospital is coarse spinach, salad, fruit, and cod liver oil. It is high time that we should return to our former habits of thinking of the digestibility of a diet, at least often enough so that we will see to it that the material put into a handicapped digestive tract is not full of woody material.

There are many good suggestions in this book and it should be of interest to every hospital dietitian. There are many diet lists and many recipes. What bothers the reviewer is the lack of good sense on the part of men who seem to think they can fit one diet to a patient with an anal fissure and another to a patient with hemorrhoids. This assumption of omniscence is a common mistake made by writers on dietetics. An author seems to think that in order to sell his book he must include a diet list for every known disease. Actually when no three "authorities" on diet will agree as to what should be given to a patient with any one disease, what is the use of trying to devise one diet for gastroptosis and another for enteroptosis? The man with good sense must see that the science of dietetics has not advanced to the point where any such accuracy is possible. He who thinks he can do this sort of thing should go shooting with three sizes of shotgun; one for ducks, one for grouse, and another for pheasants.

GROSSE ARZTE: EINE GESCHICHTE DER HEILKUNDE IN LEBENSBILDERN. By Prof. Henry E. Sigerist. München, J. F. Lehmanns, 1932.

This work by the new Professor of Medical History at Johns Hopkins, is, as its title indicates, a history of medicine in biographic

form. Short biographies are given of forty-seven important figures in medicine from Imhotep through Pettenkofer. The author has the remarkable faculty of saying much in few words and making it interesting at the same time. His viewpoints are stimulating and for every German-reading physician and student this book is to be recommended for supplementary reading, no matter how large or how meager his knowledge of the history of medicine. Students of the subject will be impressed with the author's literary ability and tyros in medical history will learn much from this short volume which, it is hoped, will soon be translated into English. We look forward to many interesting contributions from Dr. Sigerist after he has become acclimated to America.

Lectures on Endocrinology. By Walter Timme, M.D. Ed. 2, N. Y., Paul B. Hoeber, Inc., 1932.

In the Preface to this work, the author states: "It is my desire that the book retain its present form and that the material be chosen for easy and rapid reading not only by the student for whom it was originally intended, but also by the busy medical man. Therefore only the most salient features of the advances in the subject of Endocrinology have been added, and are given as succinctly as may be."

Dr. Timme has succeeded well in his intention. In ten chapters, as follows: I. Introduction; II. The Thymus Gland; III. The Pineal Gland; IV. The Thyroid Gland; V. The Parathyroid Glands; VI. The Suprarenal Glands; VII. The Pituitary Gland; VIII. The Gonads; IX. Compensatory States; X. References, he gives an up-to-date, rational and consecutive concept of the present status of the science of Endocrinology.

The medical man will obtain in this volume just the insight he needs into this subject which leads so many authors into drawing on their imagination rather than adhering strictly to the facts. Dr. Timme has resisted all such temptation and has presented what the reviewer feels to be just the book that is needed by the average practitioner.

The Use of Lipiodol in Diagnosis and Treatment. By J. A. Sicard and J. Forestier. Lond., Oxford Univ. Press, 1932.

This book of 192 pages of text and 43 additional pages of bibliography and index is a result of many years' experience on the part of the originators of this method. The senior author died before completion of the work and Dr. Forestier has brought it strictly up-to-date. The subject is covered with unusual thoroughness. With the growing use of lipiodol, all roentgenologists will want this book at hand for reference and it is so written that it will also be found of interest and value by the general practitioner and the general surgeon. The authors present the case for lipiodol conservatively and modestly.

The American Illustrated Medical Dictionary. A Complete Dictionary of the Terms Used in Medicine, Surgery, Dentistry, Pharmacy, Chemistry, Nursing, Veterinary Science, Biology, Medical Biography, etc. With the Pronunciation, Derivation and Definition. By W. A. Newman Dorland, A.M., M.D., F.A.C.S. Ed. 16, Phil., W. B. Saunders Co., 1932.

An up-to-date dictionary is a requisite in the library of every physician, especially one who writes. The sixteenth edition of the famous "American Illustrated Medical Dictionary" has just appeared, completely revised and enlarged with the collaboration of Dr. E. C. L. Miller of the Medical College of Virginia. Hundreds of new words have been added and a more or less careful scanning has revealed few, if any, errors. The new edition of this dictionary is sure to retain its place as one of the most valuable reference books in the physician's library. The typography and format leave nothing to be desired.

For editors and authors, this book is indispensable whereas for the practicing physician it will answer many questions not answered in other volumes.

A Text-book of Anatomy and Physiology. By Jesse Feiring Williams, M.D. Ed. 4, Phila., W. B. Saunders Co., 1932.

The fourth edition of this work has been revised and brought up-to-date, particular attention having been paid to the chapter on Digestion, and Physiology has been elaborated throughout the entire work. The book

is well illustrated and simply written. It is a remarkable presentation of the subject for those for whom it is intended—premedical students and nurses. Each chapter is followed by practical exercises, questions and references for further study.

Having stood the test of four editions, this book may be safely recommended as a reliable guide to the elementary study of anatomy and physiology.

MINOR SURGERY. By Frederick Christopher, S.B., M.D., F.A.C.S. With a Foreword by Allen B. Kanavel, M.D., F.A.C.S. Ed. 2, Phila., W. B. Saunders Co., 1932.

The second edition of Christopher's "Minor Surgery" has been made, according to the author, "a more useful and up-to-date volume." The question of Minor Surgery is still a debatable one and many surgeons will resent some of the inclusions in this volume under this title. The information contained will be found up-to-date, reliable and accurate although, of course, the scientific surgeon will want to refer to other books for more detailed descriptions.

PHARMACOLOGY OF THE MEDICINAL AGENTS IN COMMON USE. By Stanley Coulter, PH.D., SC.D. Indianapolis, Lilly, 1932.

This pharmacology is prepared with special attention to the needs of the medical student. The main part of the text deals with individual drugs and is followed by an appendix of tables and miscellaneous information useful to the medical student. The subjects are arranged alphabetically for quick reference. Under each title there is a terse statement of the constituents of the drug, its physiological action, dosage, and brief mention of its more important therapeutic uses.

In no sense is this book intended to supplant the larger standard texts on pharmacology. On the other hand, it is the hope of its author and publishers that the use of the pocket-sized book will so interest the student in the subject that he will be led to closer studies of the great authorities on pharmacology.

THE CAUSATION OF CHRONIC GASTRO-DUODENAL ULCERS; A NEW THEORY. By J. Jacques Spira. N. Y., Oxford Univ. Press, 1931.

A reader who dips into this book here and there is likely to be impressed for a while by the many quotations from authors who have written well on the physiology and pathology of digestion. But when these quotations are studied more carefully it is found that they are poorly strung together, and sweeping conclusions are made from premises of very doubtful value. The author should have read a statement made years ago by either Huxley or Darwin to the effect that one cannot take statements made by various writers about different things and add them and subtract them with the same confidence that one uses in adding or subtracting angles in geometry or parts of equations in algebra. Even if all the statements were fairly correct they might not be able to stand the new strain put upon them, and actually, as in the present case, many of them are so wrong and so out-dated that a writer who is really conversant with the literature of his subject would never think of using them to bolster up his argument. Thus a man who knew anything about anthropology would never think of saying that, "In spite of a large consumption of fat, the Eskimo is small, stunted, and has a low resistance to disease, in contradistinction to the sun-baked but semi-starved Arab, who is straight limbed and displays a magnificent physique" (pp. 32–33).

A sample of the author's vague logic is to be found in Chapter 15 in which, on the basis of one family history, he thinks he had proved something or other. Just what it is, is doubtful. He says: "In any case, environment, i.e. the local condition, must be considered of primary importance, as it constitutes a constant influence to which the tissues have to adapt themselves in the process of subsistence and evolution, and one must agree that 'Nature shows signs of purposive adaptation to environment.' In the present case, where it is suggested that a local influence is at fault, it must be considered, if not as the controlling factor, at least as the factor that releases or sets in motion the action of other influences. But since it can be affirmed that indiscretions in the diet are undoubtedly the immediate cause of the majority of recurrences, it would be only logical to deduce

that some item in the diet is the initial factor in the causation of the disease."

The book is so puzzling in many places and the thesis of the author is so poorly presented that the reviewer is hazy about it even after two readings of the book: one for his personal information, and one for the purposes of this review. Apparently Sir Humphry Rolleston realized this defect and in his introduction tried to help the reader by summarizing the argument as follows: "Fat when introduced into the stomach regularly causes regurgitation of the duodenal contents, including bile, into the stomach; and bile salts, when mixed with the acid gastric contents, damage the mucous membrane of the stomach. Evidence in favour of the accuracy of these various events is provided by reference to the work of others, and attention is drawn to the analogous acute damage effected in the pancreas when bile passes into its ducts. The proximity of the duodenum, as compared with the stomach, to the biliary papilla is brought forward as an explanation of the greater frequency of duodenal ulcers, and of the greater difficulty in treating them as compared with gastric ulcers. Fat inhibits gastric movements, delays digestion, and though valuable from its contained vitamins is necessary in small quantities only. It is further insisted that as olive oil does not contain any vitamins there is not any rational basis for the modern treatment of gastric ulcer therewith, which was introduced into this country by Dr. Hurst in 1907. The familial incidence of peptic ulcer is explained by the author as due to identity of the food conditions (namely excess of fat) in the affected families."

Apparently Spira feels that fat is responsible for all forms of indigestion because on page 64 he says, "Careful and prolonged observations have strongly impressed on my mind the fact that all patients suffering from gastric disturbances are, without exception, unable to consume fat."

The most curious feature of the book is that here is a man who is claiming that he has found a new treatment for ulcer, a treatment that is better than anything that has gone before, and yet when one reads the six pages which make up Chapter 18 on "Clinical Experience" one finds practically nothing about the method used. A few cases are reported in which the bare statement is made that the treatment was begun and was carried out with excellent results. Apparently small doses of alkali were given, but this is nothing new. Finally he says, on page 69, "As far as the regime itself is concerned, it can be most easily worked out by anyone who understands the rationale of the theory, and there is no difficulty in teaching every patient to master the basic principles which will guide him in the choice of his food. If properly chosen this dietary will conform in all respects with what a regime should aim at as laid down by Fernandez Martinez, viz., (1) Non-irritating to the gastric mucosa; (2) rapid evacuation; (3) excite the minimum of secretion; (4) remove the hydrochloric digestion of mucous membrane; (5) fight the infection."

Surely this should be plain enough for anyone to follow and it doubtless represents a remarkable advance in our knowledge of the subject! Unfortunately for the advancement of his theory the author shows few signs of having any clinical acquaintance with the manifold problems of ulcer or of the extensive literature on the experimental production of the disease; furthermore he fails to face the troublesome fact that, thus far, fat seems to have been one of the most useful and helpful constituents of most of the diets that have been used in the treatment of ulcer.

Medical Electricity for Students. By A. R. I. Browne. Ed. 3, Lond., Humphrey Milford, Oxford Univ. Press, 1931.

This is the third edition of an elementary work on "Medical Electricity for Students." It is intended primarily for technicians and the book well serves its purposes although many of the instruments and much of the technique shown differ from American usage.

Recent Advances in Anaesthesia and Analgesia. By C. Langton Hewer, M.C., B.S. (Lond.). Phila., P. Blakiston's Son & Co., Inc., 1932.

As its title indicates, this is not a textbook of anesthesia but rather a review of the newer and most up-to-date methods. Taking for granted the knowledge on the part of his readers of the elementary facts in anesthesia, the author describes the new methods and

the physiological and pathological aspects. The book is up-to-date and yet thoroughly conservative. The keynote of his text is expressed by the author in his preface when he states: "'Safety first' as a slogan may be open to criticism for some purposes, but it is no bad motto for the anaesthetist." With this every surgeon will agree and will wish that the phase was imbedded in the mind of every anesthetist. Conservatively, yet thoroughly, the book discusses all the new drugs and methods. The bibliography at the end of each chapter is well selected. Not a bad volume to have at hand when the pros and cons of modern anesthesia are under discussion.

ANATOMY OF THE HUMAN ORBIT AND ACCESSORY ORGANS OF VISION. By S. Ernest Whitnall. Ed. 2, Lond., Oxford Univ. Press, 1932.

This revised edition of a book, which has been a favorite with ophthalmologists since 1921, has been completely brought up-to-date and many of the illustrations have been replaced by new and better ones. Well written and unusually well illustrated, with a thirty-three page bibliography and a good index, this book will be indispensable to those interested in the subject.

BOOKS RECEIVED

All books received by THE AMERICAN JOURNAL OF SURGERY are listed in this column as soon as possible after their receipt and this must be considered as adequate acknowledgement. Books that the Editor considers of special interest to our readers will be reviewed in a later issue.

ANATOMY OF THE HUMAN ORBIT. By S. Ernest Whitnall, M.D. London, Humphrey Milford, 1932.

ANNUAIRE GENERAL DE L'UNITERSITÉ LAVAL POUR L'ANNÉE ACADÉMIQUE 1932–1933. Quebec, L'Action Sociale, Lim., 1932.

ATLAS CHIRURGISCH-PATHOLOGISCHER RONTGENBILDER. By Prof. Dr. Rudolf Grashey. Munich, J. F. Lehmanns, 1932.

BIOGRAPHISCHES LEXIKON, vol. 4. Berlin, Urban & Schwarzenberg, 1932.

CARDIAC OUTPUT OF MAN IN HEALTH AND DISEASE. By Arthur Grollman, M.D. Springfield, Ill., Chas. G. Thomas, 1932.

CLASSIC DESCRIPTIONS OF DISEASE. By Ralph H. Major, M.D. Springfield, Ill., Chas. G. Thomas, 1932.

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PERIPHERAL NERVE INJURIES

LEWIS J. POLLOCK, M.D., AND LOYAL DAVIS, M.D.

TENTH INSTALLMENT

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Chapter XXIX

THE BRACHIAL PLEXUS (*Continued*)

Sensory Symptoms

The sensory loss of brachial plexus lesions is rarely coextensive with the motor disability. It is not as reliable an index to the extent or severity of the injury as is motor loss.

Soon after injury the sensory loss is quite extensive but it rapidly shrinks so that some months later the motor loss may be complete for a certain localization whereas little sensory loss may be found (Figs. 247–251). At times complete sensory loss may be found and the motor disability be slight. This is particularly true of lesions of the inner cord. In the latter case, as has been found in ulnar nerve lesions, the sensory loss is often complete when but slight motor disability exists. Sensory loss coextensive with motor paralysis was usually seen in lesions of the fifth or the fifth and sixth cervical roots. The same condition was met with when the injury affected the fully formed peripheral nerves (Figs. 252, 253 and 254).

Attention should be called to the fact that with the exception of root lesions and primary cord lesions the sensory loss consequent to injuries of the brachial plexus corresponded neither to a root nor a peripheral distribution.

In upper plexus lesions, usually root or primary cord, the sensory loss corresponded closely to a root distribution. At times even when the biceps was not paralyzed there was an analgesia over part of the sixth cervical segment. In a lesion which produced a paralysis of the deltoid, biceps and brachioradialis muscles, the sensory loss never extended to that part of the hand usually attributed to the sixth cervical segment. On the other hand, when in addition to the biceps the pronator radii teres was paralyzed, the sensory loss was found over the radial side of the palm, including the index finger and thumb (Fig. 255). That this represented the sensory supply

of the outer head of the median nerve is further supported by such cases as showed, among other things, a paralysis of the muscles supplied by the median nerve, with the exception of

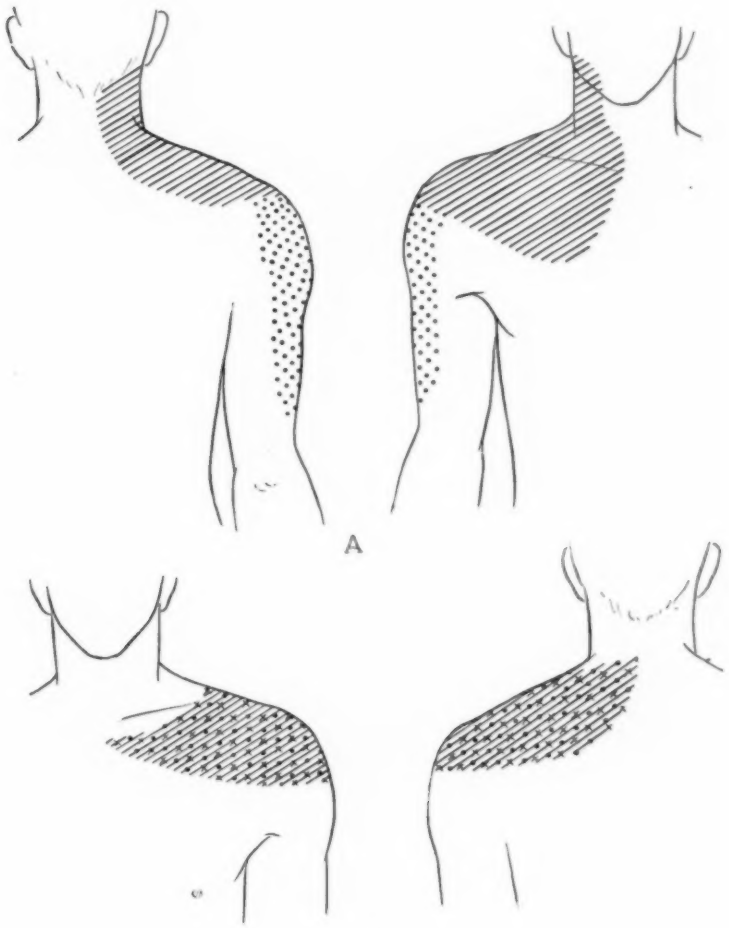

FIG. 247.

A. Sensory loss in lesion of cervical third and fourth roots.
B. Sensory loss in lesion of cervical fourth root.

the pronator radii teres alone or together with the flexor carpi radialis. In these instances sensation was unaffected over the radial part of the palm.

In Figures 256 and 257, the former a lesion of the inner primary cord and the latter a lesion of the posterior and inner cords, the radial side of the palm was sensitive as well

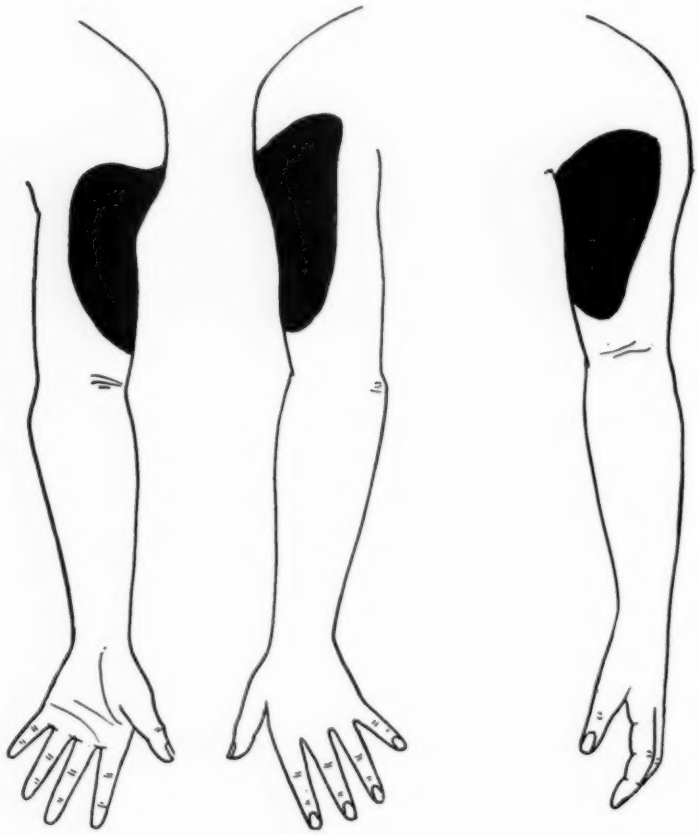

FIG. 247.

c. Sensory loss in lesion of cervical fifth root.

as the palmar surface of the thumb. It may be concluded, therefore, that the sensory area of the outer secondary cord of the brachial plexus is represented by the sensory distribution of the musculocutaneous nerve and that part of the median which supplies the radial surface of the palm, the thumb and part of the index finger. This part of the median sensory supply would then correspond to the anterior division of the seventh cervical root (Fig. 258).

The inner cord is represented by the sensory supply of the medial cutaneous nerves of the arm and forearm, the ulnar, and the median, with the exception of the thumb, part of the

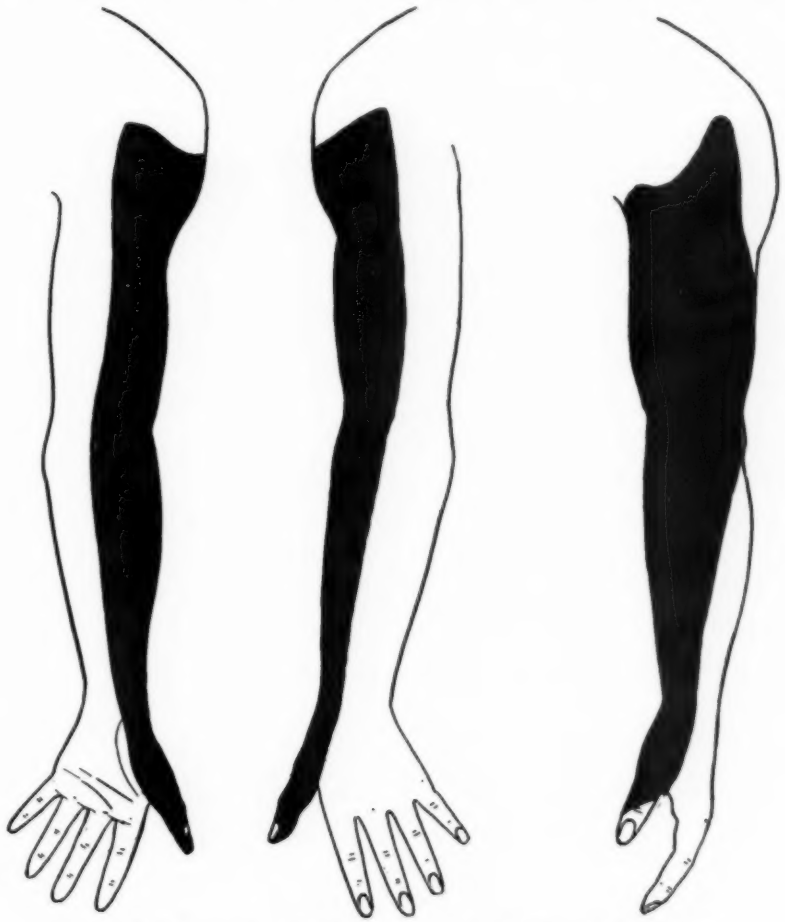

FIG. 248. Sensory loss in lesions of cervical fifth and sixth roots.

index finger and the radial side of the palm.

SIGNS OF RECOVERY

Lesions of the brachial plexus have a tendency to recover. Often the recovery is only partial, but it may become complete in from a few months to two years. In upper plexus lesions the biceps and brachialis anticus recover before the brachioradialis. The rhomboids, pectoralis major, latissimus dorsi and teres

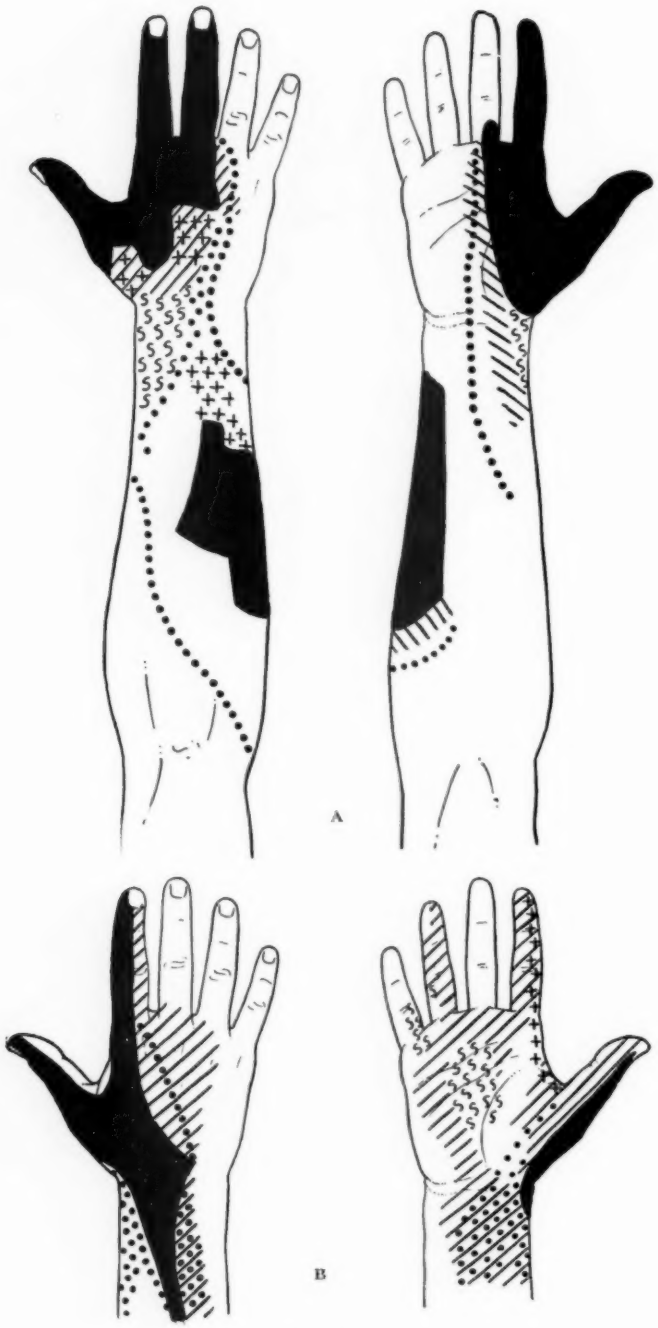

FIG. 249.

A. Sensory loss in lesion of cervical sixth and seventh roots.

B. Sensory loss in lesion of cervical sixth and seventh roots and partial lesion of cervical eighth root.

major are often only partly paralyzed and frequently recover early. The deltoid, infraspinati and brachioradialis require a longer time to recover completely.

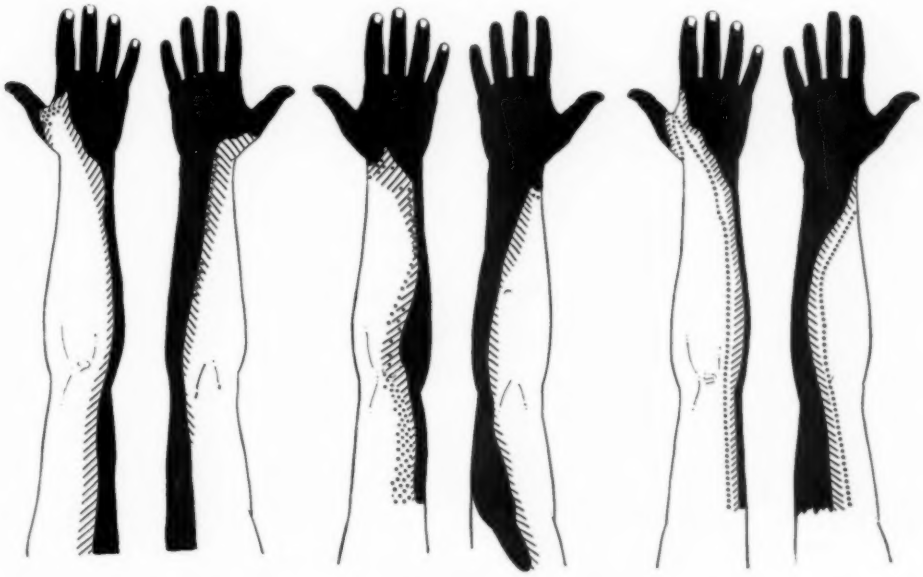

FIG. 250. Sensory loss in lesions of cervical seventh and eighth, and dorsal first and second roots.

The characteristics of the recovery of sensation in brachial plexus lesions are shown in Figure 259.

COMBINED LESIONS OF THE BRACHIAL PLEXUS AND SPINAL CORD

Brown-Séquard paralyses frequently occurred as the result of gunshot injuries. It is to be expected that injury to the roots may occur on the side of the injury to the spinal cord. At times, however, cases have been observed in which the symptoms, sensory and motor alike, corresponded neither to a root lesion, an intramedullary or a peripheral nerve lesion (Gordon Holmes). Such cases undoubtedly belong to the group described by Marie and Bénisty. Immediately following a gunshot wound in the neck the injured man falls paralyzed in

all extremities. Within a few days function is recovered in one arm and leg, leaving a spastic paralysis of the lower extremity on the side of the injury and a flaccid paralysis in the upper

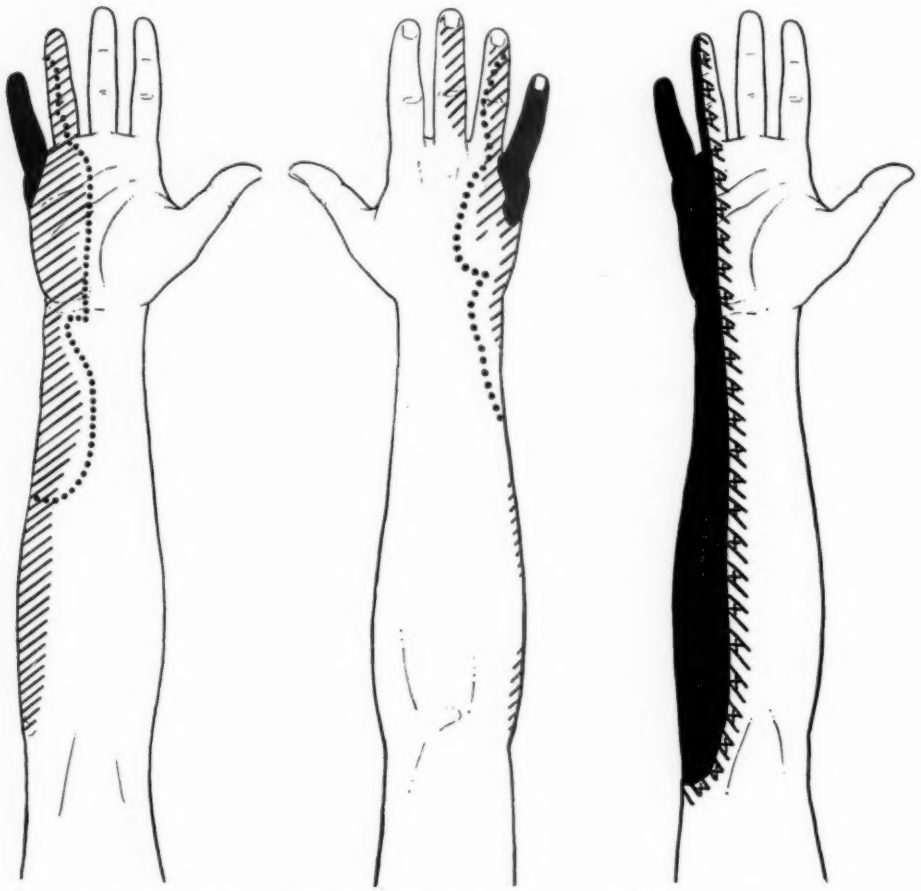

FIG. 251. Sensory loss in lesions of cervical eighth and dorsal first roots.

extremity, with a loss of sensation to pain and temperature sense on the opposite side of the body, below the level of the lesion. The paralysis in the leg spontaneously and often rapidly disappears, leaving a long lasting flaccid paralysis in the upper extremity which is due to a lesion of the brachial plexus. Often the wound of entrance was about the face, mouth or jaws and at times there occurred a paralysis of the

seventh or twelfth cranial nerves. A paralysis of the cervical sympathetic was also common.

We have the records of only ten such cases, although we

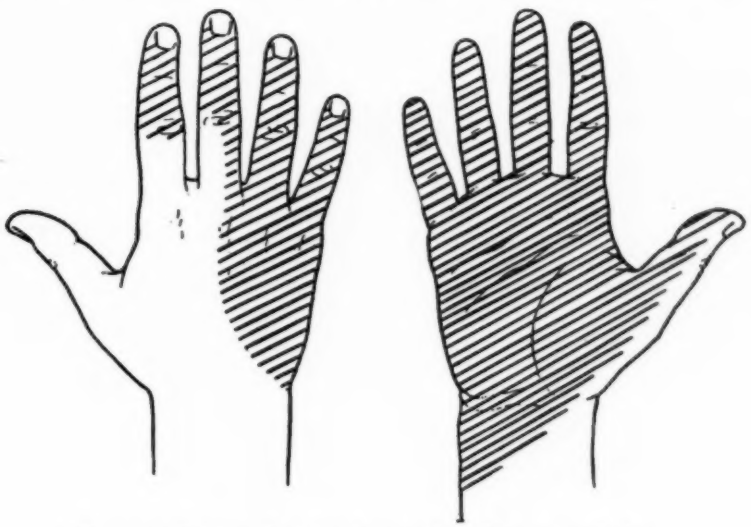

FIG. 252. Sensory loss in ulnar and median nerve lesion.

remember seeing a number of others. They exhibited a similar symptomatology and course and a description of one will suffice.

V. E. N., Pvt., 26th Infantry, was wounded July 18, 1918. A gunshot wound had been received at the angle of the inferior maxilla with the exit of the bullet wound over the second cervical spinous process. He felt the missile strike him and was thrown into the air. At first he had tonic and then a few clonic jerks in his extremities which were then paralyzed. He began to use his right leg two days later, then his right arm, and shortly after he regained some power in his left leg. When admitted to U. S. B. H. No. 13, on September 19, 1918, he was able to perform all movements with the right lower extremity with good power. There was moderate weakness in the muscles of the left lywer extremity, the flexors of the legs being the weakest muscles. All of the muscles of the right upper extremity were very weak. There was a paralysis of all of the muscles of the left upper extremity, with the exception of the deltoid, biceps, brachialis anticus, latissimus dorsi, pectorals, levator anguli scapulae and serratus magnus, which were very weak. The deep reflexes in the lower extremities were increased and were greater on the left side. In the upper extremities they were absent,

with the exception of the biceps, which was brisk on the left and normal on the right. The superficial reflexes were absent on the left side and a Babinski reflex was present. There was a Horner's syndrome on the left

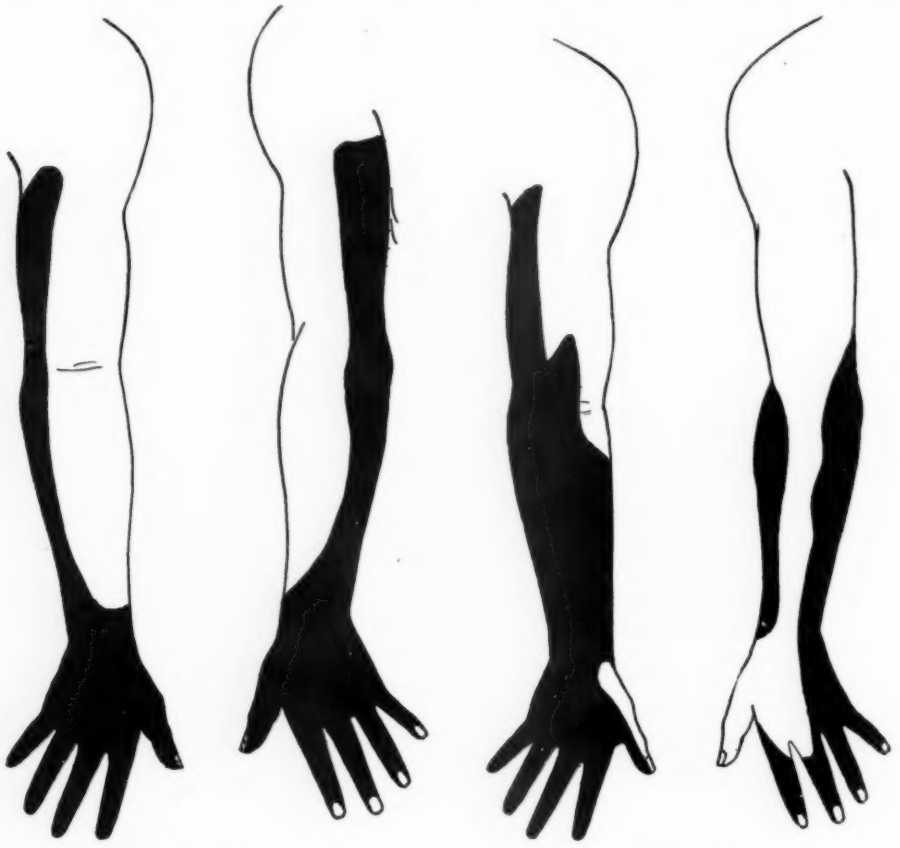

FIG. 253. FIG. 254.

FIG. 253. Sensory loss in lesion of ulnar, median, radial and medial cutaneous nerves of arm and forearm.

FIG. 254. Sensory loss in lesion of ulnar, median, musculocutaneous and medial cutaneous nerves of arm and forearm.

side. There was an hyperesthesia of the left side of the body below the second dorsal segment. There was an analgesia and a loss of temperature sense on the right side distal to the sixth cervical segment, and loss of sensation over the fifth, sixth, seventh and eighth cervical segments on the left.

Particularly interesting are such cases in which the upper level of the contralateral analgesia is a number of segments

below the residual sensory loss on the side of the lesion (Fig. 260). It has been assumed from a study of Brown-Séquard paralysis that the fibers for pain and temperature senses

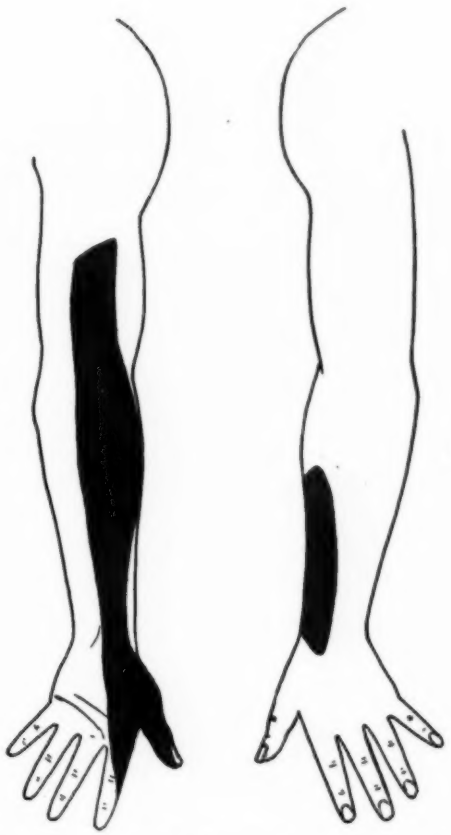

FIG. 255. Analgesia of thumb and index finger when pronator radii teres is paralyzed.

require a number of segments for complete crossing in the cervical cord. The observation that these fibers cross more directly in the dorsal region points out the possibility that the sensory loss which results from a brachial plexus lesion may be misinterpreted as that due to a cord lesion. It is possible that the absence of a thoracic plexus has led to a more accurate interpretation of the crossing of protopathic fibers in this locality.

Anatomy

The muscles of the extremities may receive their innervation from more than one segment of the spinal cord. This

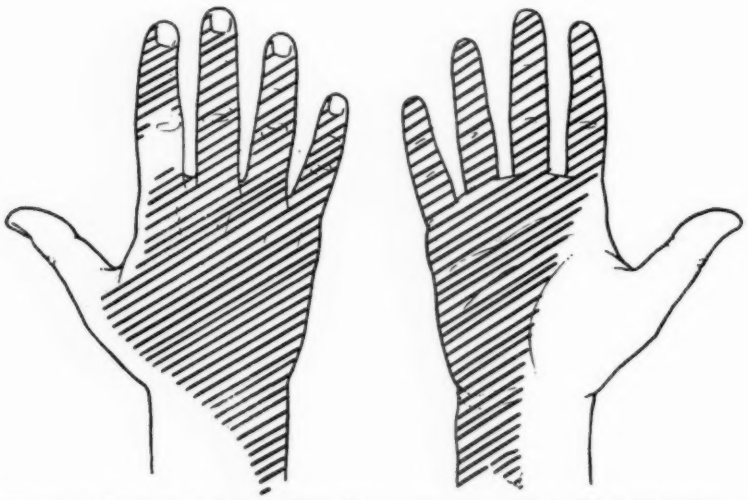

Fig. 256. Sensory loss in lesion of inner primary cord of brachial plexus.

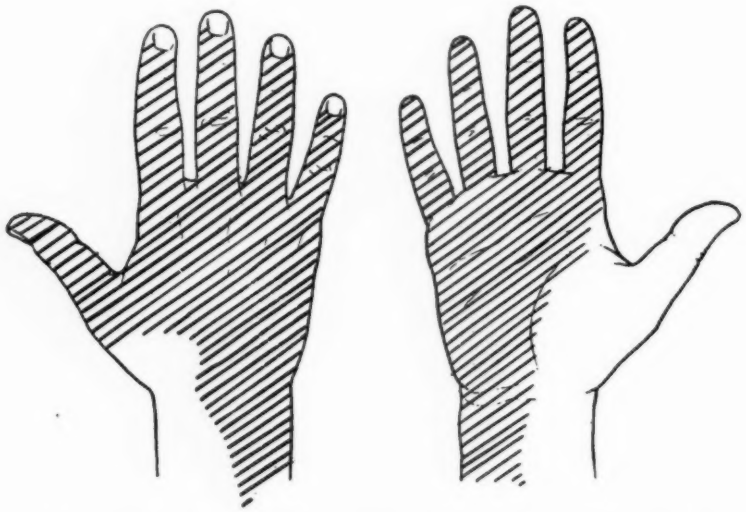

Fig. 257. Sensory loss in lesion of posterior and inner cords of brachial plexus.

anatomical fact accounts for the development of nerve plexuses for the upper and lower extremities.

The brachial plexus consists of the anterior branches of the spinal nerves which are distributed to the muscles and skin of the shoulder girdle and upper extremity. The fifth, sixth,

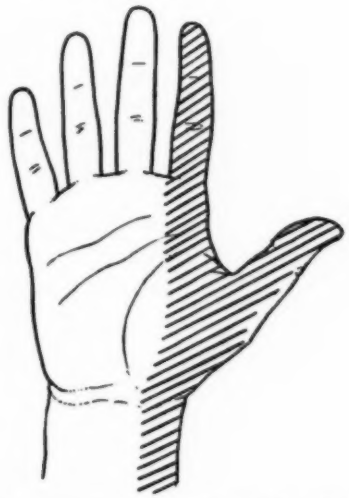

FIG. 258. Sensory representation of outer head of median nerve.

seventh and eighth cervical and the first thoracic spinal nerves form the brachial plexus. There may be variations in this arrangement of the plexus and the two most common forms are those which occur in the pre-fixed and post-fixed types. In the former the plexus receives a large contribution from the fourth cervical spinal nerve. In the post-fixed type the second dorsal spinal nerve contributes to the formation of the plexus. A difference in the type of plexus in the two upper extremities may exist in the same individual.

The plexus is situated in the posterior triangle of the neck and lies upon the dome of the pleura. It lies behind the clavicle and gives rise to its terminal branches within the axilla. Roughly, the plexus has the form of two triangles apposed to their apices. The base of the superior triangle lies against the vertebral column. Its external and superior side has an oblique direction downward and externally. The inferior side lies upon the superior orifice of the thorax and the dome of the pleura. The inferior triangle is smaller and is less regular in shape.

It lies within the axilla and its base corresponds to the origin of its terminal branches.

The anterior branch of the fifth cervical spinal nerve unites

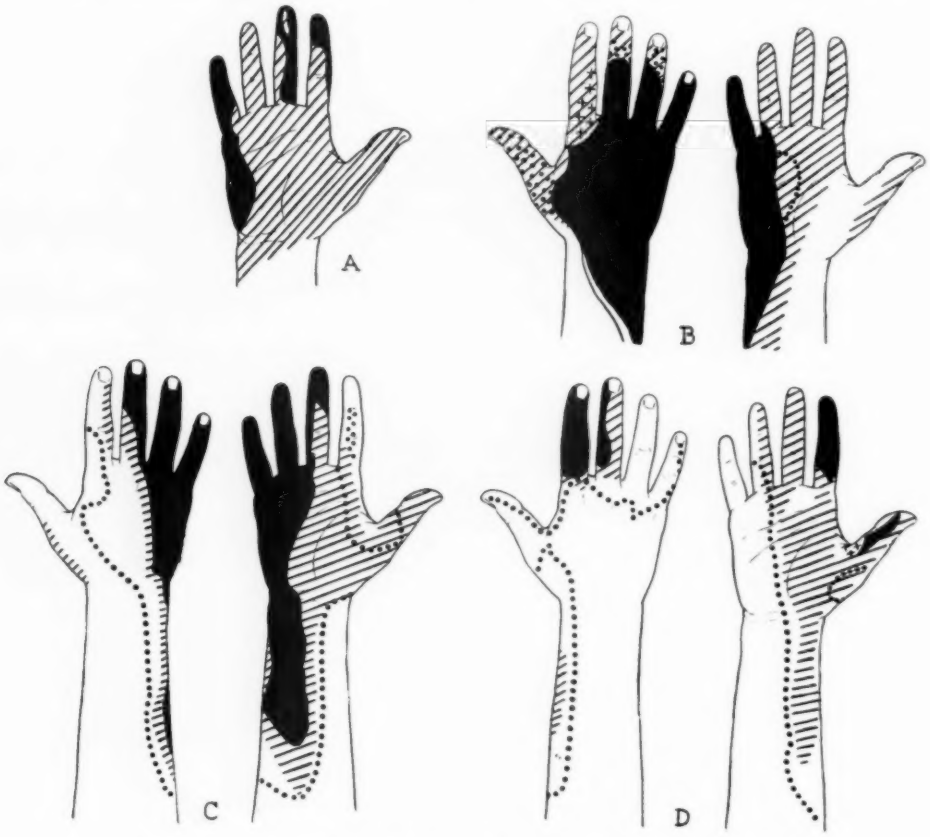

FIG. 259. Sensory loss in recovering lesions of brachial plexus.

A. Patch of return of pain in isolated supply; recovery between adjacent nerves.

B. Recovery of pain, not touch.

C. Interlacing of loss of cold; return of touch in isolated supply; recovery of touch and not cold.

D. Recovery of touch, not cold; patchy return of touch.

at an acute angle with the anterior branch of the sixth cervical spinal nerve to form the *upper primary trunk* of the plexus. The anterior branches of the eighth cervical and first thoracic spinal nerves unite to form the *lower primary trunk*. The anterior branch of the seventh cervical nerve lies between these two trunks and forms the *middle primary trunk*. Each primary

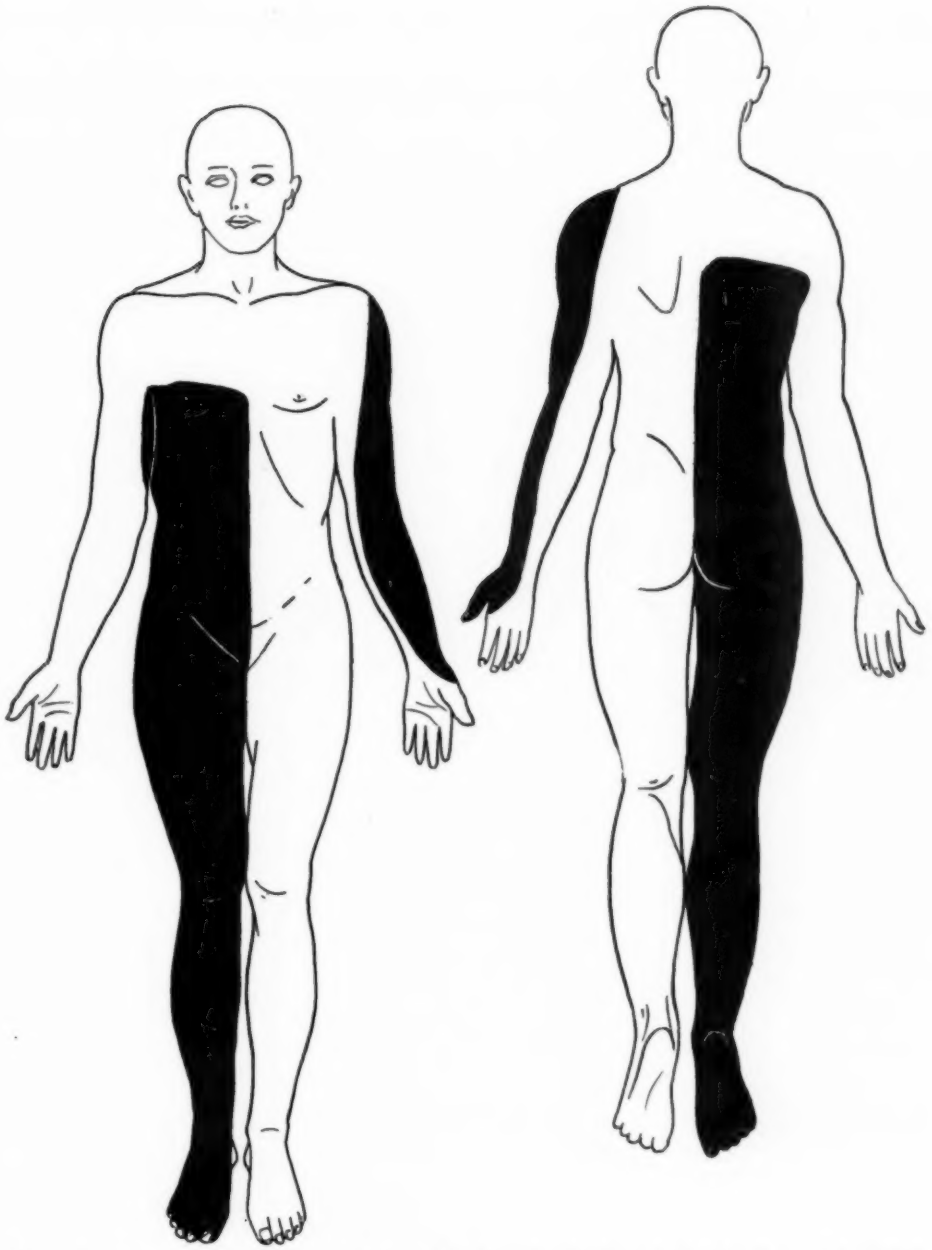

FIG. 260. Sensory loss in Brown-Séquard lesion of spinal cord with ipsilateral brachial plexus injury.

trunk divides into an anterior and posterior division. The anterior divisions of the upper and middle primary trunks unite to form the *lateral cord* of the brachial plexus. The anterior divisions of the lower primary trunk form the *medial cord* and the posterior divisions of each of the primary trunks unite to form the *posterior cord* of the plexus. The lateral cord gives rise to the lateral head of the median and the musculocutaneous nerves. The medial cord gives off as its terminal branches the ulnar, medial head of the median, medial cutaneous nerve to the arm and the medial cutaneous nerve to the forearm. The radial and axillary nerves are the terminal branches of the posterior cord of the plexus (Fig. 261).

Because of the curve of the vertebral column the roots of the fifth, sixth and seventh cervical nerves are placed more anteriorly than are those of the eighth cervical and first thoracic nerves. Leaving the transverse processes of the vertebrae, the roots pass obliquely downward and externally to enter between the anterior and middle scaleni muscles. It is not uncommon to see the fifth and sixth cervical roots pierce the anterior scalenus muscle to lie upon its anterior surface. The fifth and sixth roots unite to form the primary trunk on the scalenus medius external to the outer border of the anterior scalenus. This point is external to the outer border of the sternomastoid muscle about 2 cm. above the clavicle and is known as Erb's point. When the fourth cervical contributes to the brachial plexus, the anastomosis occurs above that point.

The eighth cervical and first thoracic roots have a much more complicated anatomical arrangement. The anterior branch of the eighth cervical and that of the first thoracic appear in the depth of a small fossa bounded externally by the transverse pleural ligament; internally, by the vertebropleural ligament; below, by the sloping dome of the pleura; and anteriorly, by the posterior extremity of the first two ribs and the vertebral column. The eighth cervical runs obliquely forward and externally to the superior surface of the

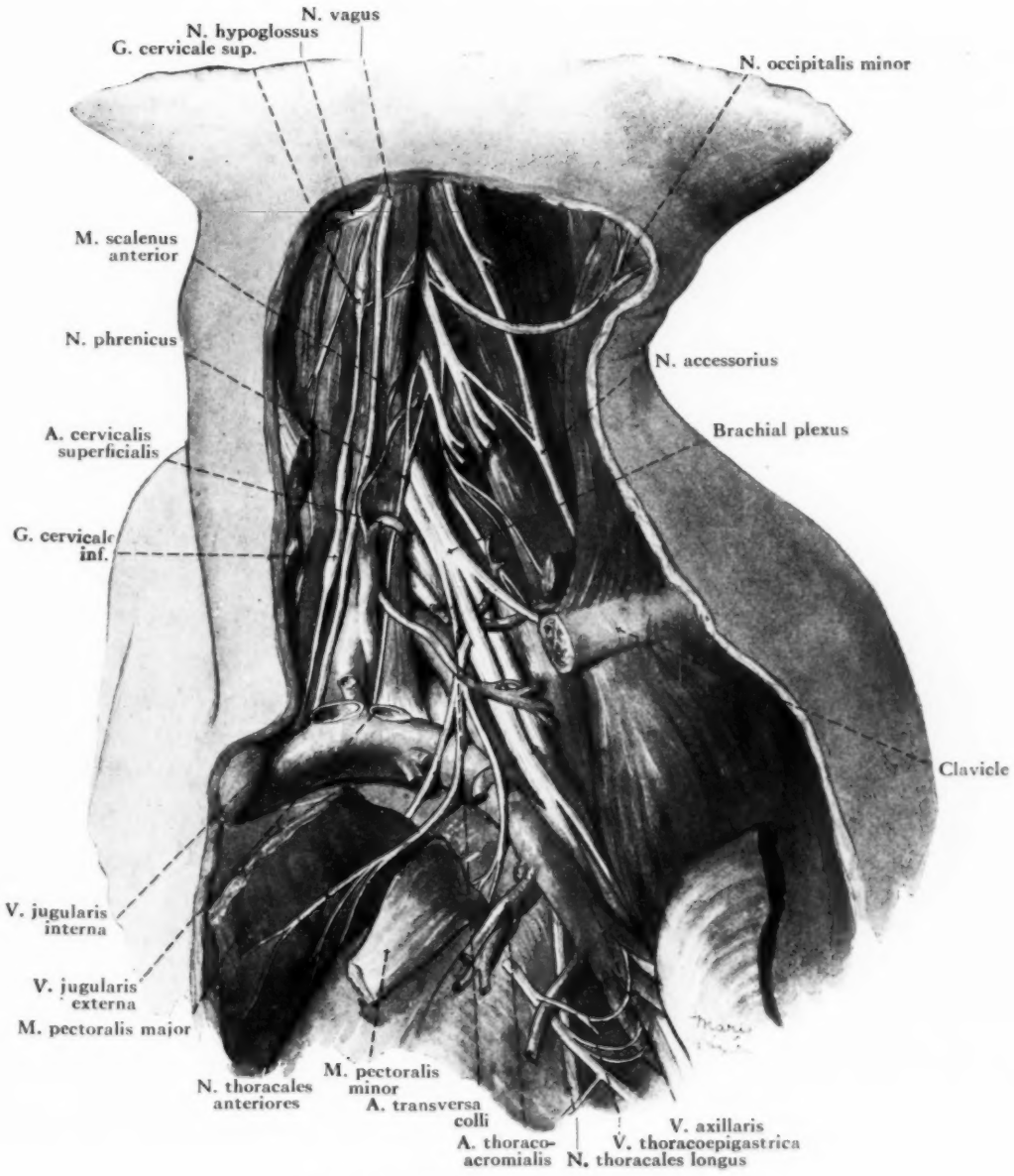

FIG. 261. Anatomy of brachial plexus.

neck of the first rib. The transverse spine of the seventh cervical vertebra overhangs it and it is hidden in front by the inferior cervical sympathetic ganglion. As it passes more

FIG. 262. Incisions to expose brachial plexus.

externally it leaves the rib and the sympathetic ganglia and overlies the dome of the pleura. It is hidden behind the transverse pleural ligament and at the inner border of the posterior scalenus muscle it unites with the anterior branch of the first thoracic nerve. The latter appears below the neck of the first rib, occasionally it is in contact with it, and passes forward and externally to cross the internal border of the rib. The costopleural ligament lies over the root which is in contact with the dome of the pleura. As it passes from beneath the ligament it unites with the eighth cervical. The contribution of the second thoracic to the plexus, when it is present, is usually very slender.

Beneath the clavicle the primary trunks give rise to the anterior and posterior divisions, which, as has been pointed out, form the cords of the plexus. The nerves lie upon the middle and posterior scalenus muscles and are bound to them by a very strong aponeurosis. The plexus is crossed obliquely by the omohyoid muscle and may be said to occupy the two

triangles of the neck which are divided by this muscle. The large part of the plexus is found in the inferior, or omoclavicular, triangle. The fifth, sixth, seventh cervical roots and the upper primary trunk occupy the omotrapezial triangle. The inferior primary trunk lies deeply upon the first rib in the space between the anterior and middle scaleni, and is difficult to see without dividing the clavicle. It is in intimate relation with the subclavian artery which in general lies anterior and below this part of the plexus.

The superficial transverse cervical artery appears at the external border of the scalenus anticus muscle. It passes upward and externally to the anterior border of the trapezius. In so doing it crosses the upper and middle primary trunks. The posterior scapular artery appears between the scaleni, passes posteriorly and externally and after a short ascending course becomes quite tortuous. It lies anterior to the middle primary trunk and finally passes between it and the upper primary trunk.

Superficially, the plexus is hidden by the superficial and middle layers of the cervical aponeurosis and the fibers of the platysma. The external jugular vein, as it appears at the posterior edge of the sternomastoid, is separated from the plexus by these layers of fascia but after perforating them at the sternoclavicular angle, it runs medially toward the subclavian and there lies close to the inferior primary trunk.

Below the clavicle and in the apex of the axillary space the lateral, medial and posterior cords are formed. They are intimately related to the axillary artery which they separate from the axillary vein. Externally lie the lymphatic chain and glands which drain the upper extremity. Just below its superior edge and posterior to the pectoralis minor muscle the cords of the plexus give rise to their terminal branches. Each of these nerves will be described separately in detail.

As has been stated the fourth cervical and second thoracic spinal nerves may have a branch of anastomosis with the plexus. In addition there are anastomoses with the sympa-

thetic ganglia in the cervical region. To each of the cervical spinal nerves a grey ramus communicans runs from the sympathetic chain.

Certain collateral branches arise from the constituent roots of the plexus before the lateral, medial and posterior cords are formed. These may be divided for convenience into those supplying the muscles on the anterior and posterior aspects of the shoulder girdle. There are six posterior branches. The *dorsalis scapulae* (nerve to the levator anguli scapulae and the rhomboids) and the *long thoracic* (nerve to the serratus anterior) arise from the posterior aspect of the roots. The *upper and lower subscapular nerves*, the *thoracodorsalis* (nerve to the latissimus dorsi) and the *nerve to the teres major muscle* arise from the posterior surface of the primary trunks.

The *dorsalis scapulae* nerve arises from the fourth and fifth cervical roots. At first it rests upon the scalenus medius to which it may send a twig, and then it passes obliquely down and externally between that muscle and the posterior scalenus. It is applied to the anterior surface of the levator angulae scapulae muscle to which it sends two or more twigs. Curving about the inferior border of the muscle the nerve lies between the small serratus superior in front and the rhomboids behind. It descends upon the anterior surface of the latter near the spinal border of the scapula. The terminal twigs supply the rhomboids throughout.

The *long thoracic* nerve arises by two or three roots. The first comes from the fifth cervical and occasionally from a trunk common to the dorsalis scapulae. The second and third roots come from the sixth and seventh cervical roots. The first two are quickly united and pierce the middle scalenus muscle. The lower root joins the nerve after it has already given off a twig to the upper digitations of the serratus anterior. The nerve passes through the axilla behind the branches of the brachial plexus which it separates from the vessels. It descends vertically upon the superficial surface of the serratus anterior about 3 to 4 cm. behind the line of emergence of the lateral

perforating branches of the intercostal nerves. The external mammary artery accompanied by a lymphatic chain lies between the nerve and these perforating branches. The nerve gives off twigs to the serratus anterior muscle along its posterior border. Certain digitations, especially the superior ones, may receive more than one twig of supply.

The *upper subscapular nerve* arises from the upper trunk of the plexus and therefore receives fibers from the fifth and sixth cervical spinal nerves. Soon after its origin it follows the external border of the upper cord and then courses inferiorly and internally along the spinal border of the scapula. Its twigs are distributed to the upper half of the subscapular muscle. The *lower subscapular nerve* may be given off directly from the posterior cord of the plexus or it may arise by a common trunk with the axillary. The nerve descends upon the anterior surface of the subscapular muscle external to the upper subscapular. It is distributed to the lower fibers of the subscapular muscle.

The *nerve to the teres major* muscle has a variable origin. It may arise directly from the posterior cord or from a common trunk with the axillary. The nerve courses inferiorly and medially and crosses the inferior and external border of the subscapular muscle to which it gives a few twigs. It may cross the inferior scapular artery to reach the teres major at the external border of the scapula. It divides into a variable number of twigs, which pierce the anterior surface of the muscle and supply it along its entire length.

The *thoracodorsalis* nerve arises directly from the posterior cord of the plexus. It receives fibers from the sixth, seventh and eighth cervical spinal nerves. It descends upon the subscapular muscle external to the nerve to the teres major. The nerve borders the anterior surface of the latissimus dorsi in the axilla and then gives off collateral twigs to supply it throughout its extent.

There are four collateral branches which supply the muscles on the anterior aspect of the shoulder girdle. The *supra-*

scapular nerve arises from the lateral cord of the brachial plexus and therefore receives fibers from the fifth and sixth cervical roots. It lies between the lateral cord and the long thoracic nerve. This nerve is one of the largest of the collateral branches. It crosses the first digitation of the serratus anterior and behind the clavicle it passes laterally around the pectoralis minor together with the suprascapular artery, to enter the suprascapular notch. The nerve is distributed to the supraspinatus and infraspinatus muscles. The *nerve to the subclavius muscle* arises from the upper primary trunk and receives fibers from the fifth cervical constantly and occasionally from the sixth. The nerve crosses the external edge of the anterior scalenus muscle to reach the subclavius at the junction of its middle and inner thirds. In its course it is crossed by the superficial transverse cervical and the posterior scapular arteries, and is hidden by the posterior border of the sternomastoid. It gives off an important branch of anastomosis to the phrenic nerve. The *external anterior thoracic nerve* almost constantly has two parts which arise from the upper primary trunk and from the middle primary trunk. It receives fibers from the fifth, sixth and seventh cervical spinal nerves. Both parts of the nerve descend in front of the axillary artery. They pierce the clavicular-pectoral aponeurosis and are distributed to the under surface of the pectoralis major. The superior one of the divisions supplies the clavicular fibers while the inferior trunk innervates the sternal fibers. The *internal anterior thoracic nerve* arises from the lower primary trunk. It receives fibers from the eighth cervical and first thoracic spinal nerves. It descends behind the axillary artery which it crosses just external to the origin of the external mammary. It receives an anastomosis from the external anterior thoracic nerve. It is distributed to the under surface of the pectoralis minor muscle.

Physiology

The physiologic action of the muscles supplied by the terminal branches will be described under each of those nerves

in detail. The muscles innervated by the collateral branches of the plexus are:

The *levator anguli scapulae* muscle passes from the superior angle of the scapula to the transverse process of the first four or five cervical vertebrae. It raises and rotates inward the superior angle of the scapula. The *rhomboid muscles* pull the scapula upward and toward the median line. This approximates its inferior angle to the vertebral column, and steadies the vertebral border of the scapula. Thus it is easier to draw the arm backward and outward.

Contraction of all of the fibers of the *serratus anterior* muscle carry the scapula forward, outward and upward. It is an important accessory muscle of respiration. It contracts with the pectoralis major to push forward with the shoulder. It assists the deltoid in raising the arm from the side. The *subscapularis* muscle rotates the arm inward. The *teres major* raises the shoulder, brings the inner aspect of the arm and the axillary border of the scapula together and draws the humerus backward. The *latissimus dorsi* muscle depresses the shoulder, draws the arm inward, rotates it backward and brings the scapula to the midline. When both latissimus dorsi muscles contract simultaneously the shoulders become less prominent and are carried obliquely backward and inward.

The *supraspinatus* muscle lifts the humerus and draws it forward and outward. Its action is strong enough to raise the arm when the deltoid is paralyzed. The *infraspinatus* rotates the head of the humerus outward. The *pectoralis major* muscle adducts and draws the arm forward when it is fully contracted. The upper part of the muscle draws the point of the shoulder upward and forward so that if the arm is raised to the vertical, contraction of this portion of the muscle draws the shoulder forward and toward the midline. It also depresses it to the horizontal and in this action is aided by the lower portion of the muscle. The *pectoralis minor* draws the shoulder forward. It assists the serratus anterior muscle in the performance of this action. The *subclavius muscle* depresses the clavicle. If the

shoulder girdle is fixed it is capable of raising and fixing the first rib in inspiration.

Surgery

Traumatic lesions of the brachial plexus are common in civil and military life. They may be produced directly by blows upon the side of the neck or shoulder, or by penetrating wounds; or indirectly by stretching or avulsion of the roots of the plexus. The mechanism of these indirect injuries is the same in adults or infants in whom they are encountered most frequently as birth palsies. The mechanism consists of depression of the shoulder while the head and neck are turned to the opposite side. This increases the angle between the shoulder and neck. If the injury is severe the upper roots may be avulsed completely. This occurs usually external to the intervertebral foramina. The upper trunks may be overstretched so that the nerve sheath remains intact. In such cases spontaneous regeneration might occur more often were it not for certain anatomical facts. The prevertebral layers of the deep cervical fascia covers the plexus closely and hemorrhage beneath this fascia may be responsible for dense scar tissue which produces serious compression. The relation of the plexus to the apex of the lung and the important vessels in the neck make penetrating wounds particularly dangerous. Combined lesions of the axillary artery or its branches and the plexus may be characterized by an hematoma and subsequent scar tissue formation. Posttraumatic aneurysms are not infrequent complications of an injury to the plexus low in the neck. All of these possible lesions of associated structures seriously complicate the surgical treatment of plexus lesions.

The results of the surgical treatment of severe plexus lesions are disappointing. This is due to the location of the lesion within or near the intervertebral foramina which makes it surgically unapproachable or to involvement of the cord when the roots are avulsed within the spinal canal. If the roots are divided they must be repaired with the closest regard to the approximation according to the original anatomical and

physiological pattern. Even though regeneration of nerve fibers may occur the function which results from a distortion of nerve pattern may make an arm useless. In many of the less severe lesions a careful, painstaking neurolysis will produce a surprisingly good result in function.

The entire brachial plexus may be exposed by an incision which consists of three parts (Fig. 264). The first is the longitudinal incision which parallels the posterior border of the sternomastoid muscle. The second portion is placed horizontally parallel to the clavicle and the third portion is a continuation of the latter incision over the anterior aspect of the shoulder to the medial side of the coracoid process and extends along the medial border of the biceps tendon to below the insertion of the pectoralis major. Any one of these three incisions may be used to expose the upper or lower parts of the plexus or they may be combined to expose it in its entirety.

The prevertebral layer of the cervical fascia should be exposed and the transverse cervical vessels ligated. The fascia is divided and the lateral border of the scalenus anticus muscle should be identified and exposed as it lies beneath the sternomastoid. The upper trunk appears from the lateral border of the scalenus anticus and lies upon the scalenus medius. If the lesion is lower down, it may be necessary to divide the clavicle. Holes should be drilled through the clavicle to facilitate its later approximation with wire. A Gigli saw should be used to divide it subperiosteally. To obtain a complete exposure of the subclavicular portion of the plexus it may be necessary to divide the insertion of the pectoralis major muscle from the humerus and the pectoralis minor from the coracoid process. Division of the subpectoral fascia will expose the nerves and vessels and by retracting the divided ends of the clavicle upward the cords of the plexus may be followed upward or their terminal branches may be followed downward. Care must be taken to preserve the anterior thoracic nerves which supply the pectoral muscles. Occasionally, direct injury to the axillary artery or compression by scar tissue may reduce it to the appearance of a fibrous cord.

Chapter XXX

THE SCIATIC NERVE

It is difficult to determine the frequency of injuries to the sciatic nerve because often when one or the other of its terminal divisions is either injured alone, or predominately injured, the condition is classified as peroneal or tibial nerve injury. From the material of Mann, Gundermann, Thoele, Spielmeyer and Reichmann, the sciatic was injured in 8.18 per cent; the peroneal in 12.28 per cent and the tibial in 2.4 per cent. Roeper and Wexberg reported 33 per cent, including the branches; and Toby Cohn found the sciatic or its branches injured in 122 cases in a group of 513 cases. The sciatic trunk was injured in 51 of these; the peroneal in 29; the tibial in 26; and both in 15 cases.

In our material, both branches of the sciatic were injured in 160 cases; the peroneal branch above the bifurcation in 11; and the tibial in 2 cases. Below the bifurcation the peroneal was injured in 120 cases; the tibial in 25; the anterior tibial in 16; and the posterior tibial in 16 cases.

In addition to gunshot and stab wounds, injury of the sciatic nerve may result from fracture of the femur. This may occur immediately as the result of direct injury, or later from callus formation. It occurs as the result of reduction of dislocations of the hip. It occurs in infants as the result of injury at birth. Jumping upon the extended foot, and sudden, unexpected extension of the lower extremity with flexion of the trunk, has produced injury to the sciatic nerve. Saddlers and plasterers are predisposed to injury of the sciatic. At times cases have been observed following operative anesthesia, and it has been injured at operation. It has frequently been injured by the injection of arsphenamine, ether, alcohol and mercury. Alcoholic polyneuritis chiefly affects the sciatic nerves. They are, of course, involved in other polyneuritides, such as lead,

arsenic and those due to infectious diseases. The sciatic may be the seat of a mononeuritis as the result of an osteoarthritis of the spine or sacro-iliac joint.

FIG. 263. Deformities seen in sciatic nerve paralysis.

MOTOR SYMPTOMS

Because the nerve to the semitendinosus and membranosus is given off very high, a complete paralysis of flexion of the leg is rare. As a rule, when the patient is examined in the prone

position some weakness may be made out in the biceps, and to a lesser degree in the other two muscles.

While standing, the foot dangles and drops. In walking the,

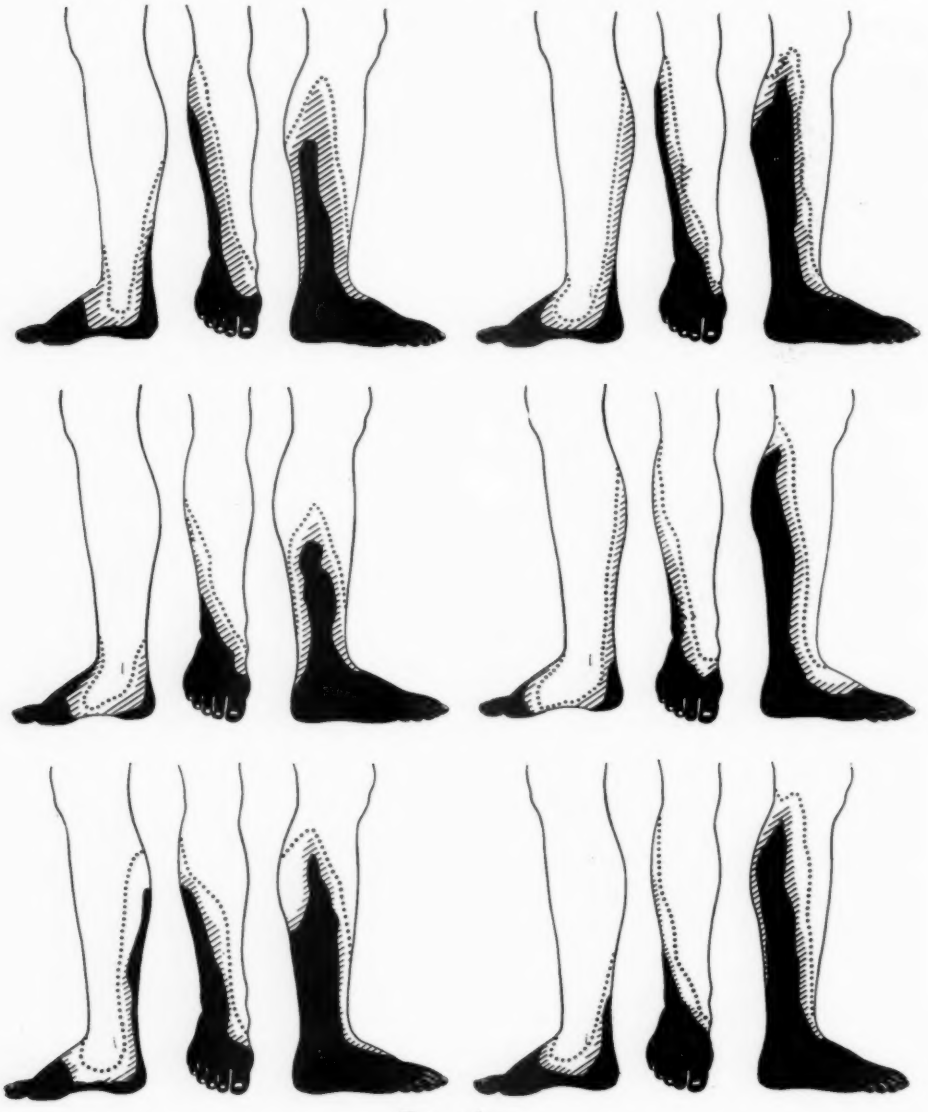

FIG. 264A.

FIG. 264. Sensory loss in sciatic nerve lesions. A. Sciatic.

knee at times is carried too high and the foot is brought down somewhat as in the steppage gait of a peroneal nerve palsy.

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As time goes on, fibrosis and shortening of ligaments produces a limitation of movement of the foot and the patient may walk with relatively little disability, using the paralyzed

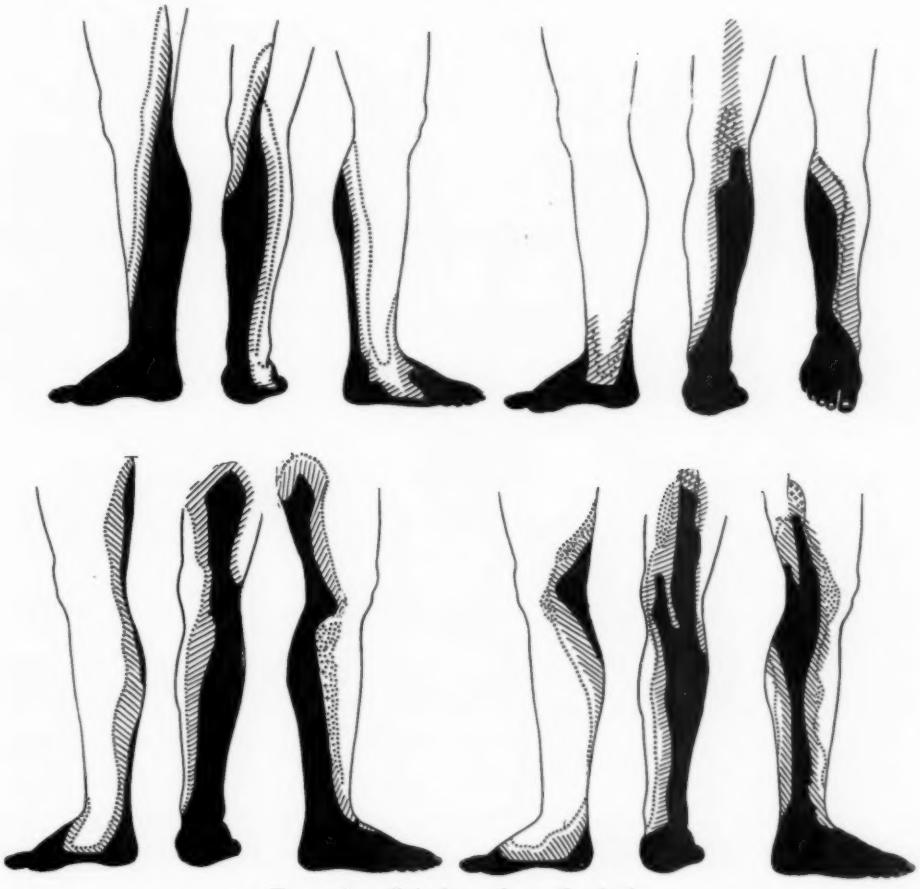

FIG. 264B. Sciatic and small sciatic.

extremity much as a peg leg. All of the muscles below the knee are paralyzed and the patient cannot stand on his heels or toes. Running is impossible. (Fig. 263.)

Atrophy of the muscles is often concealed by the edema and infiltration of the tissues of the leg. When it is observable, in some cases pronounced atrophy of all of the muscles may be seen. The knee jerk is always present and the Achilles jerk is always absent. When the plantar reflex is sought for by

stimulating the inner side of the sole, contraction may occur in the fascia lata, but no movement is seen in the foot.

Supplementary Movements: Interpretation of muscle

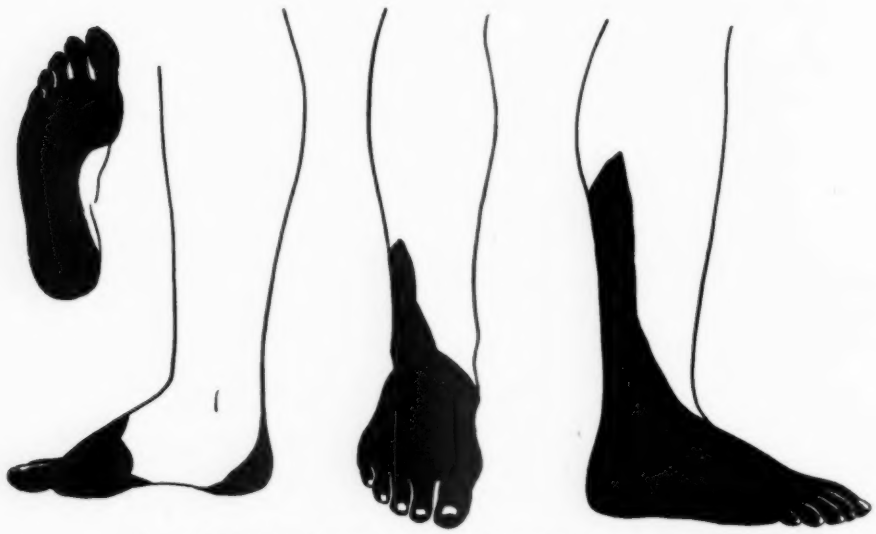

Fig. 265. Isolated supply to pain in a sciatic nerve lesion.

function in the lower extremity is much simpler than that in the upper, chiefly because of the minor importance of the intrinsic foot muscles as compared with those of the hand. Attention has been directed chiefly toward the movements of the larger muscles in the lower extremity. Inasmuch as such supplementary movements can occur only when one of the divisions of the sciatic nerve is totally paralyzed and the other partially or not at all involved, description of these movements will be made under the heads of the peroneal and the tibial nerves.

Sensory Symptoms

Objective sensibility is diminished or lost over the entire foot, with the exception of the inner border of the arch and the internal malleolus. It is lost over the dorsum of the foot, over both sides of the heel and the outer side of the leg to the knee (Fig. 264).

The overlap of adjacent uninjured nerves is considerable, so that the upper level of the loss of pin prick may extend only to the middle third of the leg. Above this only epicritic sensibility was found lost over the accepted sensory distribution of the nerve. The overlap to deep sensibility elicited by an algometer was greater than to pain, and pressure pain could be felt above the ankles. It is noteworthy that we could never elicit sensation by pinching the toes in a case of complete section of the sciatic nerve (Fig. 265).

In complete lesions subjective sensory disturbances are usually negligible, except for a very short time following injury. The sensory loss contributes largely to the disability in producing unsteadiness of gait.

Vasomotor and Trophic Changes

As the result of ankylosis, injury to the sole is common. Vasomotor changes, and perhaps some trophic disturbance which interferes with the healing, make ulcerations common. Often an ulcer may follow some slight abrasion beneath the ball of the great toe. It may progress to a fully developed perforating ulcer which involves the joint.

Edema of the leg and foot is common, and brawny infiltration of the calf is seen. The foot is often purplish in color, warmer than normal and has a distinctly dry skin.

Plantar hyperkeratosis is of frequent occurrence. The satin-like skin over the dorsum of the foot is often covered by scales and at times crusts. Sweating is diminished except over the inner border of the foot and the internal surface of the leg. The ball of the foot is frequently more prominent, and the toes may be hyperextended at the first phalanges. (Fig. 266.)

Partial Lesions

Dissociated or partial paralysis may be due to a greater damage to either the tibial or the peroneal branches, or to partial injury of both. Operative and clinical experience shows that the peroneal suffers greater damage, as a rule, than the

tibial. Of a series of 37 cases seen soon after injury, the muscles supplied by the peroneal were paralyzed and those supplied by the tibial were weak in 12 cases. All of the muscles were

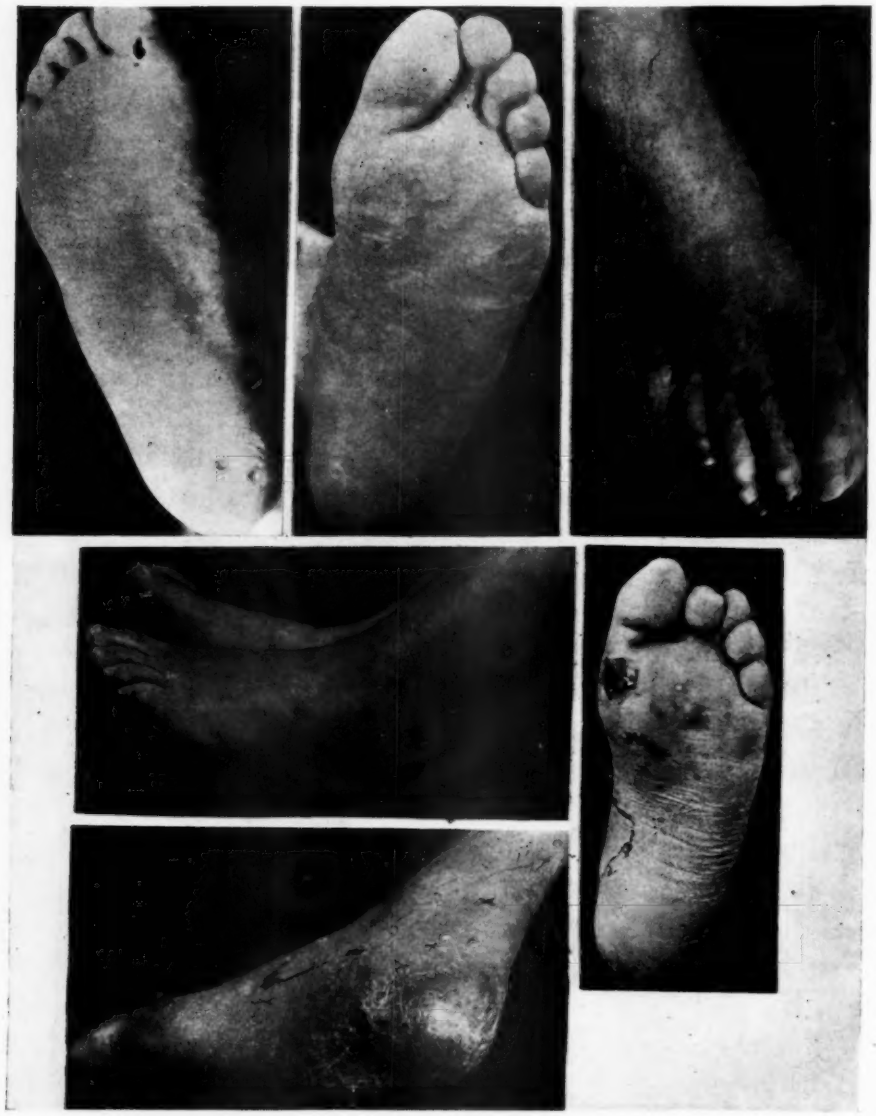

FIG. 266. Trophic disturbances in sciatic nerve lesions.

weak in 10 cases. The tibial group were paralyzed and the peroneal group were weak in 4 cases. The peroneal nerve alone

was paralyzed in 2 and the tibial nerve alone in 2 cases. The extensor muscles of the toes were paralyzed in 2 cases and all of the muscles were paralyzed in 2 cases.

Signs of Motor Recovery

According to Bénisty, the muscles which are first to recover are, according to the individual case, the tibialis anticus, the peroneus longus or the gastrocnemius. Much more rarely recovery begins in the tibialis posticus. The flexors and extensors of the toes are always the last to recover.

The Medical Research Council of Great Britain reported that, as a rule, the tibial nerve showed signs of return of function earlier than did the peroneal. Stopford's records of sutured cases showed that the order of recovery is the gastrocnemius, tibialis anticus, extensor longus digitorum and extensor proprius hallucis.

The records of the Military Orthopedic Hospital, Shepherd's Bush, gives the order of recovery in 8 cases as tibialis posticus, gastrocnemius, tibialis anticus, extensor longus digitorum, extensor longus hallucis, extensor brevis digitorum and peroneus longus.

In a group of cases in the American material it was found that in 41 recovered cases there was a return of function in the tibialis anticus in 18, in the gastrocnemius in 11; in all muscles in 9; in the tibialis posticus in 8; in the peronei in 4; in all muscles supplied by the peroneal in 3; in the flexors of the toes in one; and in all muscles supplied by the tibial in one case.

In 14 cases following suture, function returned first in the gastrocnemius in 8 cases; in the tibialis posticus in 5 cases; in the peronei in 4 cases; in the flexors of the toes in 3 cases; in the tibialis anticus in 3 cases; and in the extensors of the toes in one case.

In severe cases and following suture, return of function in the branches of the tibial occurred earlier than in those of the peroneal. Extension of the toes was very late in appearing,

and in spontaneously recovering lesions flexion of the toes occurred very late.

Signs of Sensory Recovery

Sciatic nerve lesions which recovered spontaneously occasionally showed marked sensory loss with good motor recovery. Recovery of pain sense only in the areas supplied either by the tibial or peroneal nerves occurred frequently. When sensation was returning to the sole, areas of recovery to touch and pain with loss to cold sense were seen. Areas of recovery to touch and not to cold were also observed over the leg. When sensation had partly returned in the area supplied by the tibial, the area of analgesia in the region supplied by the peroneal occupied a wider area than is seen in isolated lesions of the peroneal. Recovery of touch and pain in patchy and indented patterns occurred. (Fig. 267.)

Generally in lesions which recovered following operation, the loss of pain was more extensive. When partial recovery had taken place in the areas supplied by the tibial, the sensory loss produced by the lesion of the peroneal was very extensive. When one or the other divisions of the sciatic showed unequal regeneration, this condition was found to be the result of a lesser injury to the nerve which showed signs of first recovery. (Figs. 268.)

Painful Lesions

As was noted in the case of the median nerve, so in the sciatic nerve some injuries result in a painful type of paralysis. It has been found that only those injuries are painful which show an injury to the fibers of the tibial nerve.

During the first week complete paralysis is often present. Then motor recovery begins, most often in the region of the tibial. In some cases, however, when the peroneal branch is less injured, movements controlled by this nerve are the first to recover. As with the median nerve, involuntary movements

are sometimes observed, consisting of abduction and adduction of the foot, or flexion of the toes.

The pain is referred to the sole and at times is extremely

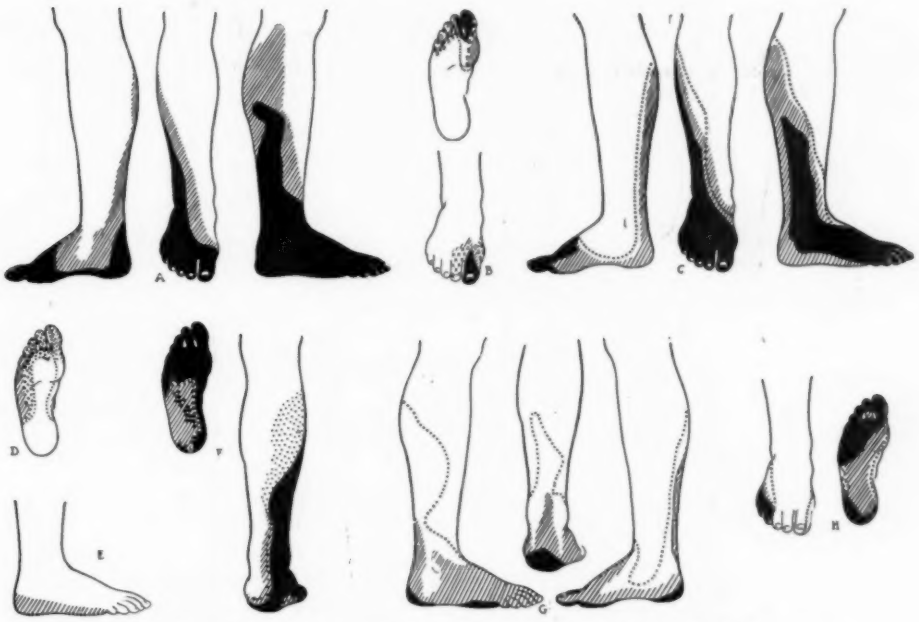

FIG. 267. Sensory loss in spontaneously recovering lesions of sciatic nerve.

A. Extensive sensory loss with marked motor recovery.

B. Recovery of touch but not of pain, and interlacing of cold sense.

C. Recovery of pain sense in tibial distribution with wide area of loss of pain sense in peroneal area.

D. Recovery of touch and pain but not of cold sense; patchy recovery of touch sense.

E. Complete recovery of peroneal and of pain sense in tibial areas.

F. Recovery of pain sense in isolated supply and cold sense in patches.

G. Recovery of touch sense in patchy areas but no return of cold sense.

H. Patchy recovery of pain sense in tibial; recovery of peroneal.

severe. Burning pain is characteristically present and is associated with a spasm of the muscles in the sole. The calf may be exquisitely tender and all contacts, especially with dry surfaces, may produce a paroxysm of pain. Slight jarring and even psychic stimuli are sufficient to precipitate a paroxysm, as in the cases of painful median nerve lesions. The chapter on Causalgia includes a description of these cases (Fig. 269).

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Anatomy

The sciatic nerve is the terminal branch of the sacral plexus. It is a large flat ribbon-like nerve about 12 to 14 cm

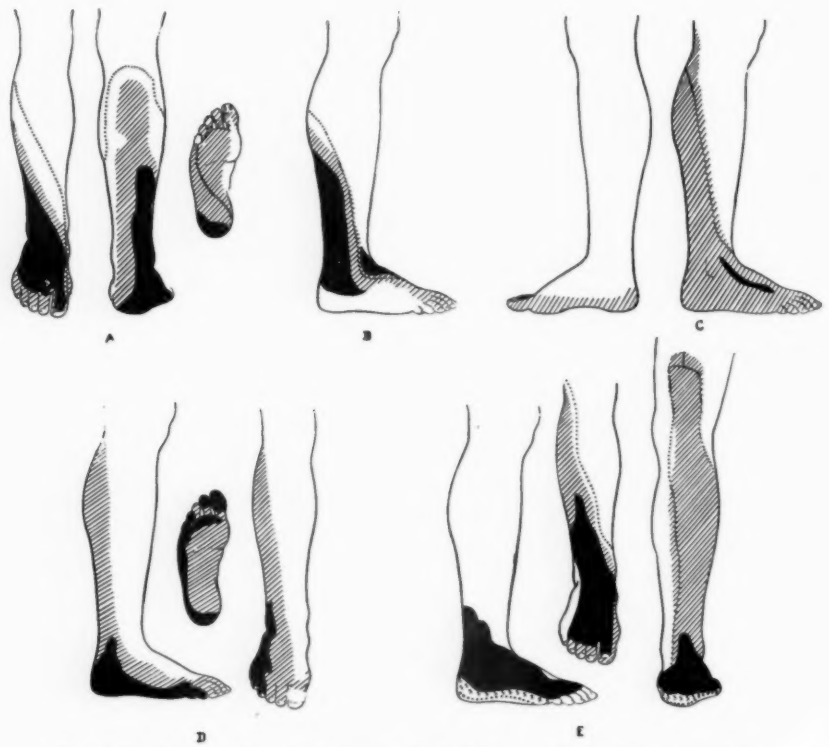

Fig. 268. Sensory loss in lesions of sciatic nerve following operation.

A. Recovery of pain and cold sense in area of tibial nerve.
B. Return of sensation in tibial, patchy return of pain, and interlacing of cold sense.
C. Marked return of pain sense.
D. Return of pain sense in peroneal; patchy return in tibial; cold sense not recorded.
E. Return of pain sense in tibial; diminished loss of touch sense.

wide and 4 to 5 mm. thick at its origin but it gradually becomes rounder as it descends into the thigh.

It is made up of the ventral and dorsal roots of the fourth and fifth lumbar, first, second and third sacral nerves. The common level of union of these roots is at the anterior border of the great sciatic foramen below the pyriformis muscle. It descends between the greater trochanter of the femur and the

ischial tuberosity through the posterior surface of the thigh to the level of its lower third. There it divides into the tibial and peroneal nerves. However, this division may occur at any

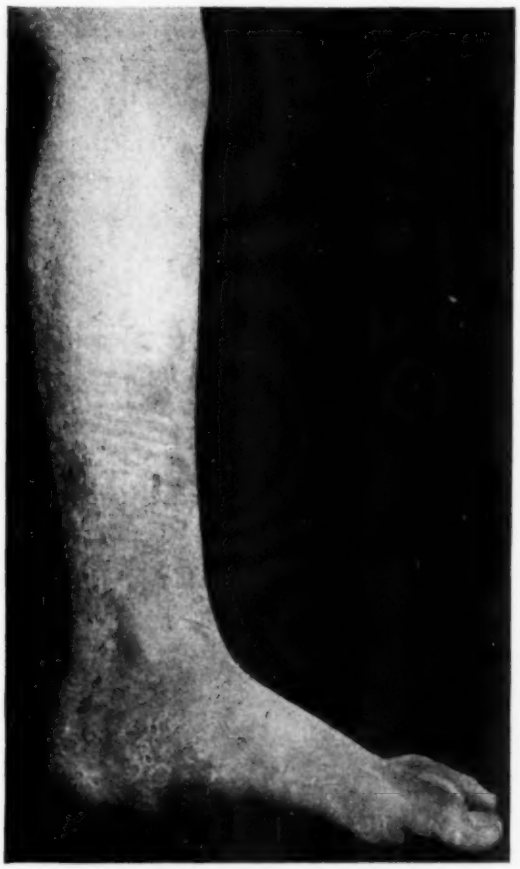

FIG. 269. Macerated skin of foot in case of causalgia of sciatic nerve.

point between the sacral plexus and the popliteal space. As has been shown, the sciatic nerve really consists of two nerves in one sheath: the tibial, which is derived from the anterior divisions and the peroneal, which originates from the posterior divisions.

Just after the nerve appears from the sciatic foramen it lies upon the posterior surface of the ischium, the nerve to the quadratus femoris muscle and the external rotator muscles of

the thigh. It is accompanied by the small sciatic nerve and artery and is covered by the gluteus maximus. In this region it is classically described as lying an equal distance from the great trochanter and the tuberosity of the ischium. In reality it is closer to the ischial tuberosity but its actual position varies with the position of the extremity.

Lower in the thigh and surrounded by its pad of fat it lies upon the dorsal surface of the adductor magnus muscle. It is covered by the long head of the biceps muscle which crosses it obliquely from within externally. The nerve is covered by skin and fascia only at the lower border of the gluteus maximus and at the entrance of the nerve into the popliteal space. Before it divides into its terminal divisions the sciatic gives rise to *articular* and *muscular* branches. Several branches which arise from the upper part of the nerve and may originate from the sacral plexus, perforate the posterior part of its fibrous capsule and supply the hip joint. All of the muscular branches arise from the internal portion of the trunk except the nerve to the short head of the biceps which originates from the external portion of the nerve. The nerve to the *long head* of the *biceps* descends obliquely and externally. It divides at the external border of the muscle into its terminal twigs which ascend and descend to supply the body of the muscle. The nerve to the semitendinosus muscle may arise from a trunk in common with the nerve to the long head of the biceps but otherwise it originates below the latter. A short branch immediately enters the superior part of the muscle while a longer branch enters the inferior portion of the muscle. Both branches lie between the semimembranosus and biceps muscles. The nerves to the *semimembranosus* and *adductor magnus* muscles arise from a common trunk. The small twig to the adductor crosses the semimembranosus and breaks into small twigs as it reaches the inner border of the adductor. The branch to the semimembranosus passes in front of the biceps and semitendinosus and supplies it on its posterior surface. The nerve to the *short head* of the *biceps* descends

parallel to the external border of the sciatic trunk, runs a more or less separate course for 12 to 15 cm. and penetrates the muscle on its medial posterior surface. Stookey states that

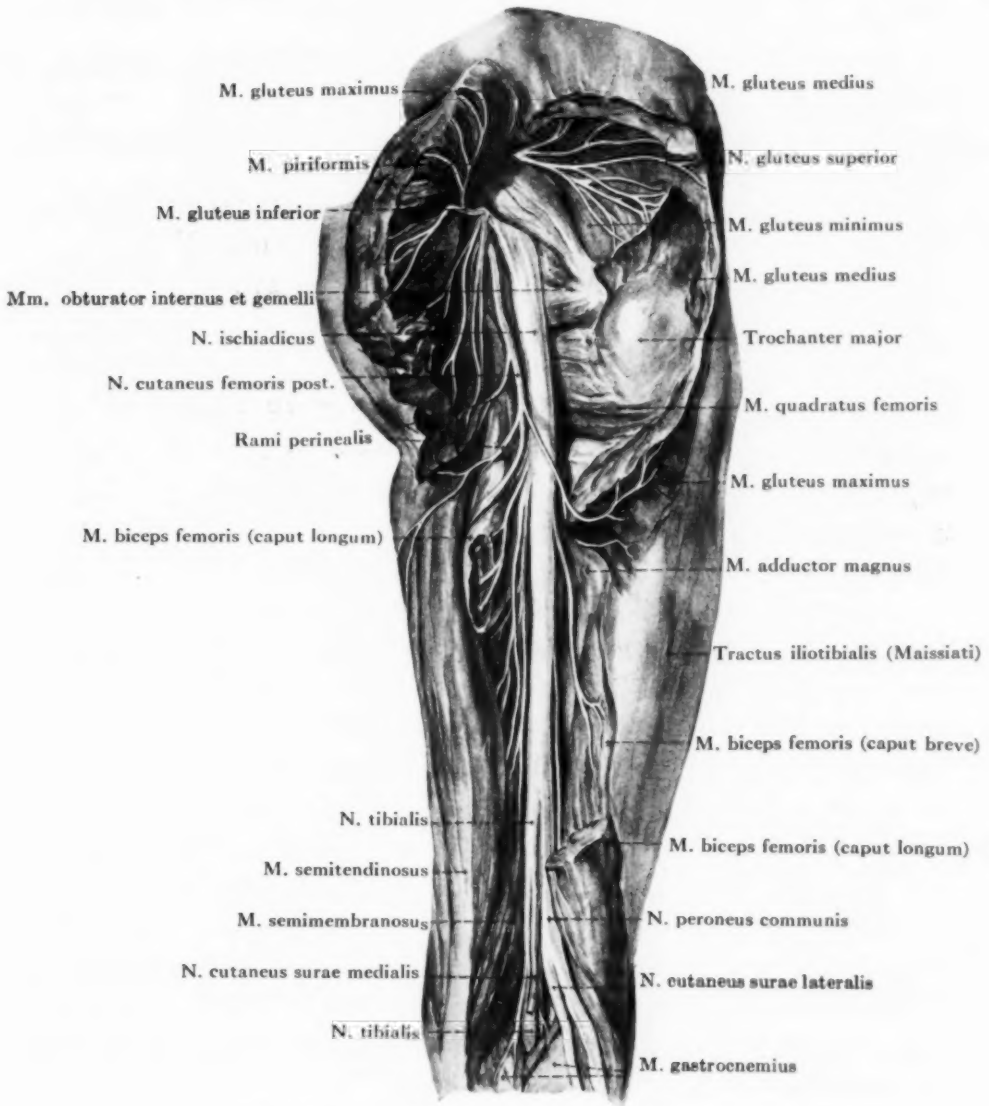

FIG. 270. Anatomical course of sciatic nerve.

the nerve from which the inner hamstring muscles are innervated arises independently from the lumbosacral plexus in

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more than 80 per cent of cases and in the remainder it is only incorporated within the sheath of the sciatic trunk. This is of clinical importance, as will be seen later. (Fig. 270.)

Physiology

The *biceps, semitendinosus* and *semimembranosus* muscles are flexors of the leg upon the thigh. According to Duchenne they also help extend the thigh upon the pelvis and rotate the leg on the thigh.

Surgery

The sciatic trunk may be pressed upon by various types of pelvic tumors which give rise to pain along its course or which may even produce a complete paralysis. Tumors growing from the pelvic bones, aneurysms of the internal iliac artery or its branches and large bladder calculi may involve the sciatic trunk. Outside the pelvis, violent movements of the hip joint, or dislocations of this joint, may produce a paralytic lesion. It is not uncommon to see patients in whom the nerve has been stretched for the relief of so-called "sciatica" and the resulting intraneural fibrosis may give rise to a lesion which requires surgical interference.

In war, injuries of the sciatic trunk are far more common than any other nerve lesion in the lower extremity. Complete severance of the nerve is not common. For the majority of cases surgery of the sciatic concerns its tibial and peroneal components, to which the clinical symptoms may be confined though scar tissue involves the entire trunk. Consequently, one should be familiar with the technique of operative approach to the sciatic and its terminal branches and moreover should be able to apply practically what is known concerning the funicular anatomy of the trunk.

To expose the sciatic nerve in the gluteal region, the patient should be placed upon his abdomen with a sandbag under the opposite shoulder and hip to permit unimparied respirations. The extremity to be operated upon should be flexed slightly

at the knee to relax the hamstring muscles. The limb should be supported beneath the foot by any convenient method so that an assistant's hands are freed. The field should be so draped that, if necessary, the incision may be extended down the thigh.

The incision recommended by Stookey is the most satisfactory. It should begin opposite the posterior inferior iliac spine and be carried downward and outward to a point about three fingers breadth medial to the greater trochanter (Fig. 271). The incision should then curve downward and medially following the curve of the gluteal fold to the middle of the thigh from which point it may be continued downward as far as is necessary. The next step is to undermine the lateral edge of the skin at its inferior margin to expose the attachment of the gluteus maximus muscle. The key to the entire operative exposure is to sever the gluteus maximus at its insertion. This should be done by dividing the upper fibers of the muscle parallel to their course and then severing the muscle attachment about 2 cm. from the femur. In this way the muscle may be reflected medially and upward together with the branches of the inferior gluteal vessels which lie upon its under surface. This avoids the severe hemorrhage and shock of divided muscle fibers which accompanies an incision made directly over the course of the nerve. Such a procedure exposes the nerve immediately from the pyriformis muscle to its entrance into the thigh. After the nerve lesion has been treated, the tendinous attachment of the gluteus maximus should be sutured strongly and little loss of physiologic function of the muscle will follow.

A straight incision which begins over the gluteal fold midway between the ischial tuberosity and the greater trochanter and extends downward in the median line of the thigh will expose the nerve at any point in its course to the popliteal space (Fig. 272). It will be remembered that the sciatic lies more superficially at the popliteal space and just below the border of the gluteus maximus muscle.

In the upper third of the thigh the lower edge of this muscle should be freed in its fascial plane and retracted upward. At the junction of the upper and middle thirds of the thigh

FIG. 271.

FIG. 272.

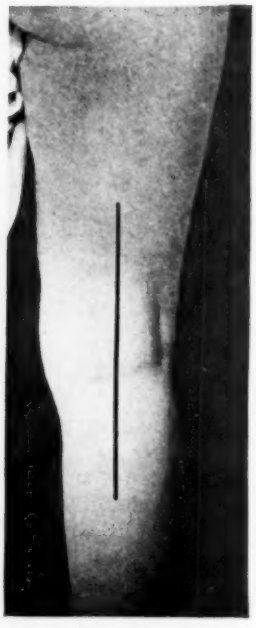

FIG. 273.

FIG. 271. Line of incision to expose sciatic nerve in gluteal region.
FIG. 272. Line of incision to expose sciatic nerve in thigh.
FIG. 273. Line of incision to expose sciatic nerve in popliteal space.

the biceps muscle crosses the nerve obliquely from within outward. Therefore, this muscle should be retracted laterally and the hamstring muscles medially. Occasionally at a slightly higher level it may be easier to retract the biceps medially. The flattened tendon of the semimembranosus muscle may be mistaken for the sciatic trunk which lies immediately along its lateral border surrounded by fatty tissue. In this latter perineural fat will be found the perforating branches of the profunda femoris artery and their accompanying veins.

The sciatic trunk may be so changed in appearance by dense scar tissue that great care should be exercised in identifying the extension of the injury accurately. The tibial division may be involved without injury to the peroneal component or

vice versa. Often the line of demarcation may not be seen and yet can be palpated. It should be remembered that the tibial component lies medially and somewhat anteriorly while the peroneal portion is located on the posterolateral aspect of the nerve. Consequently, the line of cleavage runs somewhat obliquely. It may be necessary to identify the line of cleavage nearer the popliteal space where the two nerves separate to run independently and then follow this plane upward. The use of the stimulating electrode will help in this identification, besides it furnishes evidence of the presence or absence of fiber conductivity.

A linear incision should be placed in the medial line of the popliteal space to expose both of the divisions of the sciatic nerve (Fig. 273). Both nerves lie rather superficially beneath the popliteal fascia, fat and the lower portions of the hamstring muscles. The popliteal artery and vein lie in a deeper plane. The external saphenous vein enters the popiteal vein and may be obliterated by the presence of a large amount of scar tissue. It is wise to ligate the vein so that it may not be torn off and serious bleeding from the popliteal vein is thus avoided. The latter structure is commonly involved in scar tissue and its walls are easily torn so that it must be handled with care. Attempts to remove the bed of scar tissue may have to be abandoned because of possible injury to this vein. The tibial nerve descends through the middle of the space and passes beneath the superficial muscles of the back of the leg. The peroneal nerve descends obliquely, crosses the lateral head of the gastrocnemius and passes superficially to the head of the fibula. If the dissection is started from above downward it will be easier to identify the muscular branches of the tibial which innervate the two heads of the gastrocnemius muscle. The cutaneous nerves which arise in the popliteal space need not be repaired if their union is a difficult surgical procedure because their supply is overlapped by the internal saphenous and musculocutaneous nerves. However, they should be identified so that they will not be sutured to the motor branches.

Chapter XXXI

THE PERONEAL NERVE

Somewhat analogous to the radial nerve, when injured a lesion of the peroneal nerve produces immediate and extensive paralysis of all the muscles supplied by it. As a result of the injury, a deformity characterized by foot-drop is observed. In addition to the foot-drop, a slight drop of the first phalanx of all of the toes may be seen. At times a dorsal tumor of the tarsus, which is usually due to the more or less pronounced projection of the astragalus and scaphoid bones and to the thickening of the sheaths of the extensor tendons is observed (Fig. 274).

Motor Symptoms

When examining voluntary motion it is necessary to immobilize the knee of the patient, and to be alert unless twitchings of the aponeurosis of the leg caused by contraction of the muscles of the thigh be mistaken for contraction of muscles supplied by the peroneal nerve. Under careful observation, no active movement of dorsal flexion of the foot is possible. Adduction of the foot is executed by the tibialis posticus. Extension or dorsal flexion of the proximal phalanges of the toes is impossible. The distal phalanges may be extended by the contraction of the interosseus tendon, which in the foot as in the hand extends the last two phalanges. Abduction of the foot cannot be performed (Fig. 275).

A steppage gait is characteristic. The patient walks by raising the knee high, the point of the foot is dropped and adducted. It is planted heavily upon the ground. The disability is commonly greater than when the entire sciatic nerve is severed.

Supplementary Movements: Supplementary movements of the ankle joint are observed rather frequently. Strong flexion

of the toes occasionally results in inversion and slight dorsal flexion of the foot, due to a mechanism similar to that observed in which strong flexion of the fingers produces passive exten-

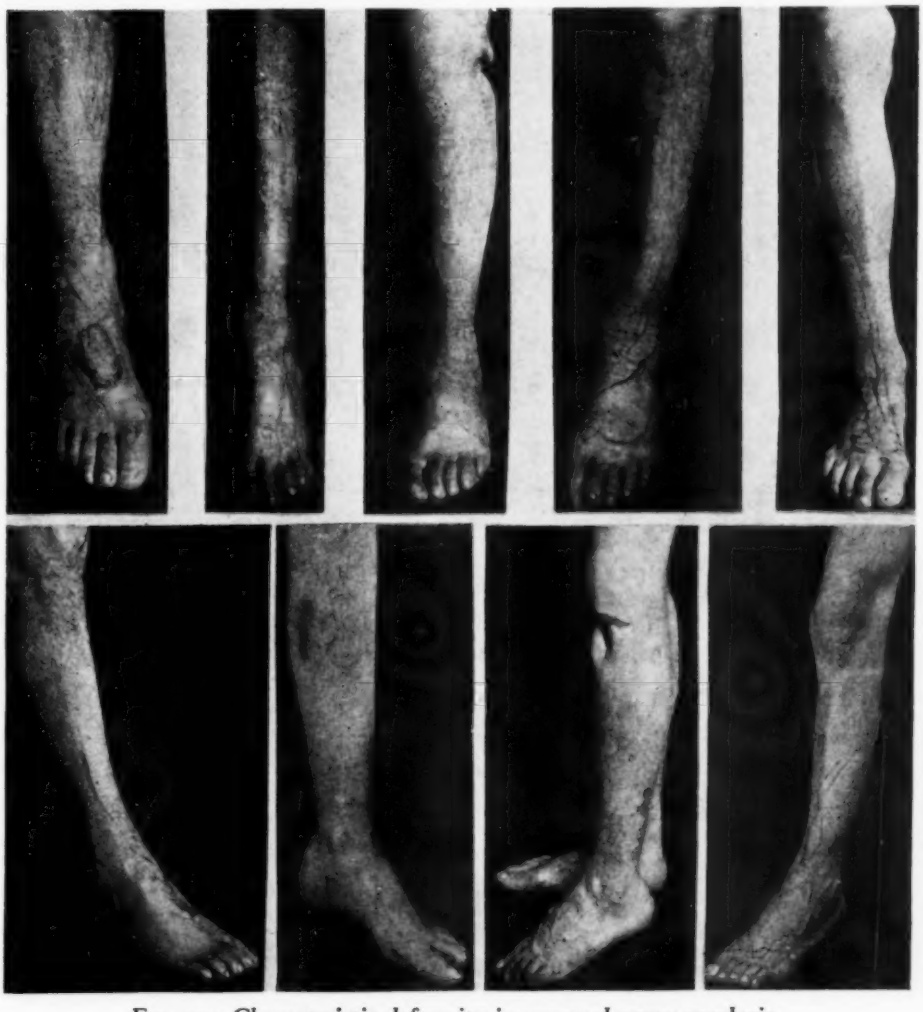

FIG. 274. Characteristic deformity in peroneal nerve paralysis.

sion of the hand in radial nerve lesions. Movements of the toes are sometimes confusing when the contraction of the antagonists of the paralyzed muscles is followed by a rebound simulating the normal action of the muscles under investigation. If the dorsal flexors of the toes are paralyzed and the

patient attempts to contract the paralyzed muscle, plantar flexion of the toes may be the initial movement, followed by a rebound of the toes to the original position.

FIG. 275. Inability to abduct foot in peroneal nerve paralysis.

SENSORY SYMPTOMS

Subjective sensory disturbances are rare. When present, they consist of aching pains in the upper outer part of the leg. At times the patient complains of a deep-seated pain in the external malleolus. When pain has been a prominent factor, the injury has been above the bifurcation of the sciatic and a slight injury to the tibial nerve has existed at the same time.

Objective sensibility is destroyed over the dorsal surface of the foot and the anterior and outer surface of the leg. In the foot, sensation is lost to the base of the toes, extending outward to a point between the fourth and fifth toes, and inward to the base of the first metatarsal bone. The upper limit varies, but in many instances may extend to the head of the fibula (Figs. 276 and 277). The borders adjacent to uninjured nerves are sensitive to pin prick and to the extremes of temperature. The isolated supply of the peroneal nerve is often surprisingly small, as was found to be the case in radial nerve lesions.

The area of exclusive supply of pain of the peroneal nerve was obtained from certified cases of division and cases which

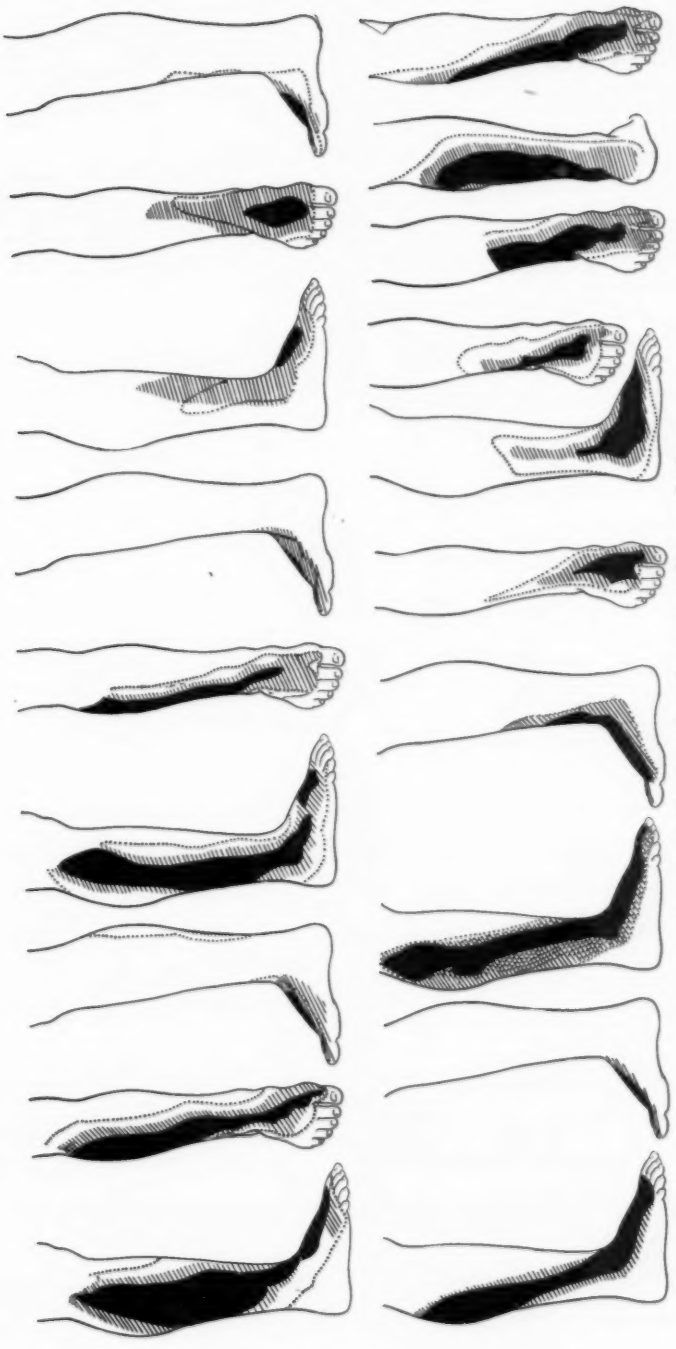

FIG. 276. Sensory loss in peroneal nerve lesions.

were examined less than thirty-seven days following resection and suture. The area consists of a narrow band which extends from a point a little above the junction of the lower and middle

FIG. 277. Sensory loss in partial lesion of peroneal nerve with superficial peroneal nerve undivided.

thirds of the outer surface of the leg, diagonally across the dorsum of the foot to a point over the middle of the metatarsal bone of the great toe. It is interrupted at the junction of its lower and middle thirds by an area which is sensitive to pin prick. The area is due to the overlap on one side of the long saphenous nerve and on the other side of the tibial nerve (Fig. 278). Although a number of cases showing such an interruption in the band of analgesia have been observed, they have not fulfilled the requirements which we demanded in estimating exclusive supply. One case showed this type of interruption of the band of analgesia twenty-seven days after resection and suture.

Our results, therefore, are at variance with those of Head, Rivers and Sherren. Referring to the fact that the unit for protopathic sense is the posterior root, they said that following

section, the peroneal nerve, which represents a large part of the fifth lumbar root, does not show a great difference between borders of the areas of analgesia and anesthesia.

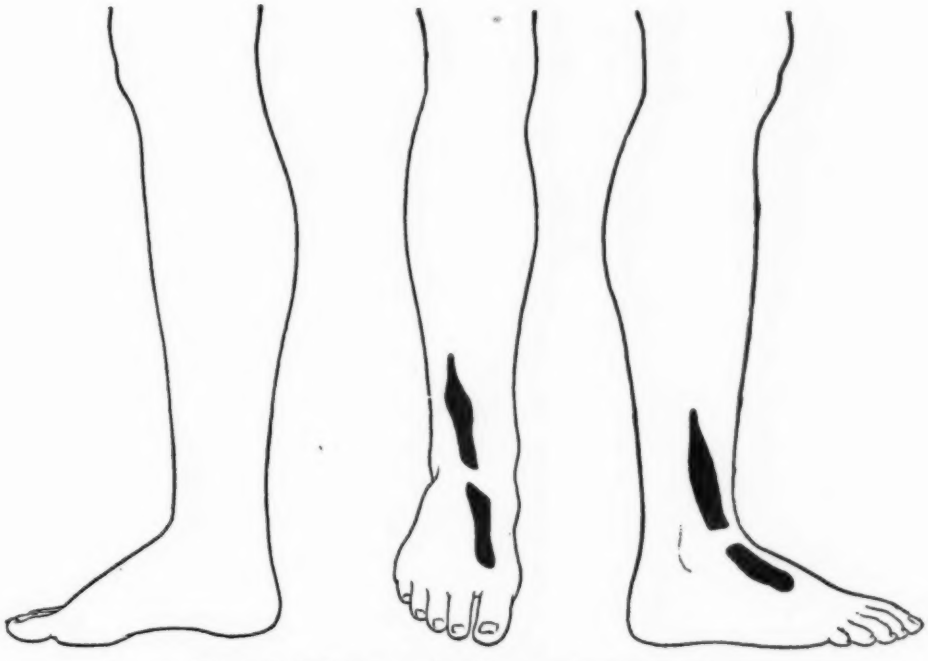

FIG. 278. Isolated supply of peroneal nerve to pain.

PARTIAL LESIONS

Cases of incomplete and dissociated paralysis of the peroneal are observed, but not frequently. They generally occur following wounds in the leg in which the superficial or the deep peroneal nerve has been injured alone. Dissociated paralysis may occur, however, in lesions above the bifurcation of the nerve. Under this condition we may have a paralysis of the tibialis anticus alone, or of the peronei muscles alone, while the extensors of the toes are spared. Occasionally the extensors of the toes may be paralyzed and the other muscles may be only slightly involved or completely spared.

Signs of Motor Recovery

The order of the recovery of motion is given by Bénisty as tibialis anticus, peronei, extensor longus digitorum and exten-

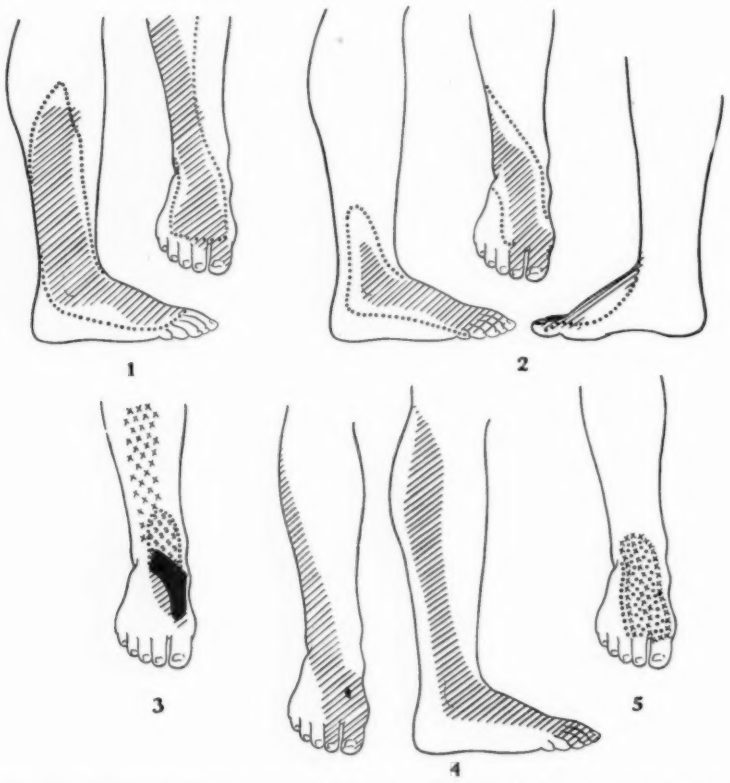

Fig. 279. A. Sensory loss in peroneal nerve lesions which recovered spontaneously. 1. Recovery of pain sense; interlacing of cold. 2. Recovery of pain sense. 3. Recovery of touch and cold sense, not pain. 4. Diminished area of loss of pain sense. 5. Recovery of touch, not pain sense.

sor proprius hallucis. Stopford agrees with this, whereas the records of the Military Orthopedic Hospital place the extensor longus digitorum first. In a small group of 29 cases in the American material which recovered spontaneously, the tibialis anticus recovered in 22 cases; the peronei in 7; the extensor longus digitorum in 3; and the other muscles in 3. Of 27 cases which had peroneal nerve sutures, 6 showed recovery. The order of return of motion was in the tibialis anticus, extensor longus digitorum and the peronei.

Signs of Sensory Recovery

Peroneal nerve lesions which recovered spontaneously frequently showed complete recovery to pain. Interlacing of the

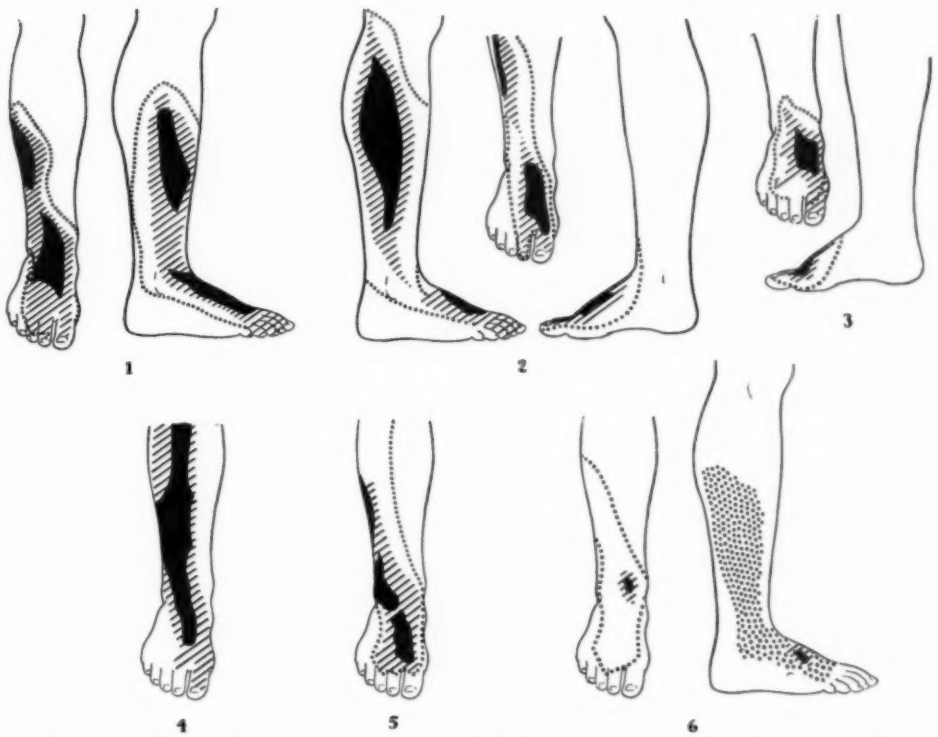

Fig. 279. B. Sensory loss in peroneal nerve lesions after operation. 1. Patchy return of pain sense. 2. Patchy return of pain and touch sense; primary suture. 3. Return of touch sense in area of isolated supply. 4. Recovery of cold sense, great toe; interlacing. 5. Patchy return of pain sense; interlacing. 6. Recovery of touch sense, not cold.

border of loss of cold was seen, particularly over the dorsum of the foot. Areas of recovery to touch and not to pain were occasionally observed. In the patients who recovered following operation, loss of pain sense was more common. In those cases patchy return of pain sense was observed very frequently. Interlacing areas which showed recovery of touch and not of cold, as was the case in the radial nerve, were noted (Fig. 279).

Anatomy

The peroneal nerve is about one-half the size of the other terminal branch of the sciatic trunk. As was pointed out it arises from the posterior divisions of the last two lumbar and the first two sacral nerves.

After its origin from the bifurcation of the sciatic trunk it descends obliquely across the popliteal space close to the medial margin of the biceps muscle to the head of the fibula. It passes between the biceps tendon and external head of the gastrocnemius muscle and winds around the neck of the fibula. It divides into the *deep peroneal* (anterior tibial) and *superficial peroneal* (musculocutaneous) nerves between the peroneus longus muscle and the bone (Fig. 280).

Previous to the division into its terminal branches the nerve gives off articular and cutaneous branches. Two of the articular branches accompany the superior and inferior external articular arteries to the outer side of the knee. The third branch arises at the point of division of the peroneal nerve. It accompanies the anterior recurrent tibial artery through the tibialis anticus muscle to supply the anterior surface of the knee joint. There are usually three or more cutaneous branches which supply the skin along the posterior and external surface of the leg. The largest branch (communicans peronei) arises near the head of the fibula, crosses the external head of the gastrocnemius to the middle of the leg and joins with the communicans tibialis to form the *external saphenous* nerve.

The *deep peroneal* descends obliquely beneath the extensor longus digitorum muscle to the anterior part of the interosseous membrane. It then descends with the anterior tibial artery to the anterior surface of the ankle joint. Here it divides into an *external* and an *internal* branch. The relation of the nerve to the artery is interesting in that it first lies lateral, then anterior and finally lateral to the artery at the ankle joint. The deep peroneal nerve in its course through the leg innervates the tibialis anticus, extensor longus digitorum, peroneus tertius

and extensor proprius hallucis muscles. It also supplies an articular branch to the ankle joint. The *external* or *tarsal* branch of this nerve passes laterally across the tarsus beneath

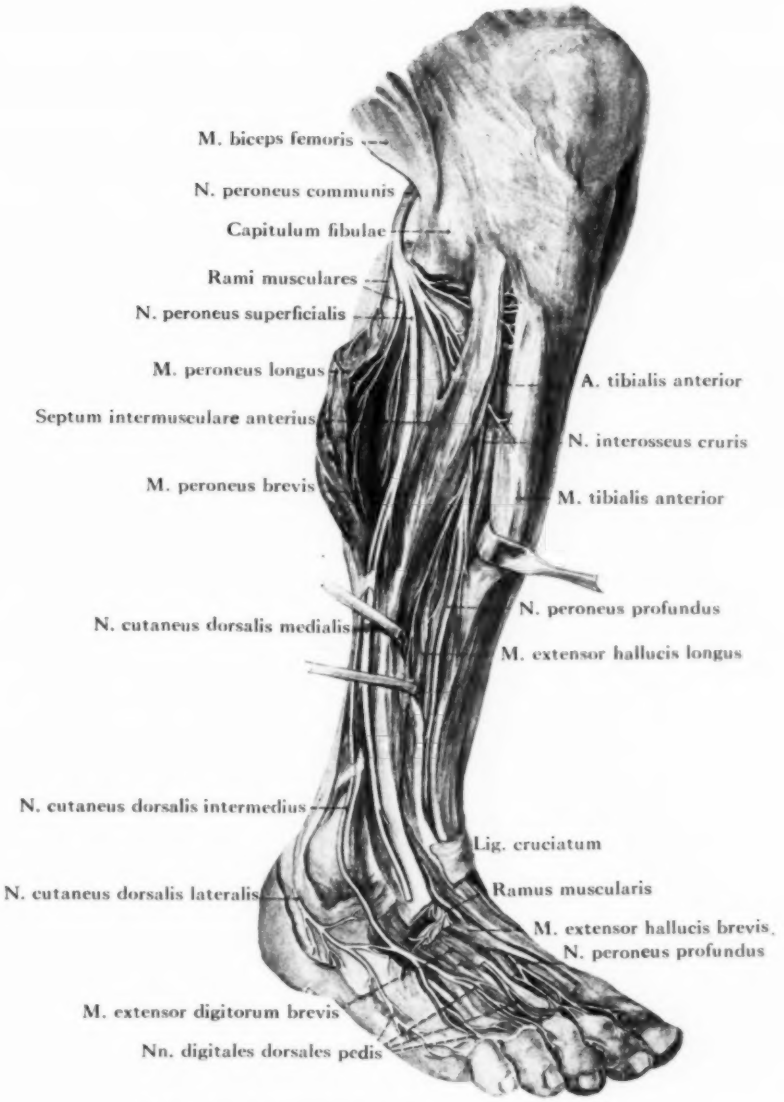

FIG. 280. Anatomical course of peroneal nerve.

the extensor brevis digitorum which it supplies. It becomes enlarged slightly and gives off three small *interosseous* branches which supply the tarsal joints, the metatarsophalangeal joints

of the second, third and fourth toes and the second dorsal interosseous muscle. The internal branch is in reality a continuation of the parent trunk. It accompanies the dorsalis pedis artery along the inner aspect of the dorsal surface of the foot. It divides into two dorsal digital branches which supply the adjacent sides of the large and second toes. It also gives a twig to the metatarsophalangeal joint of the great toe and a branch to the first dorsal interosseous muscle.

The superficial peroneal passes anteriorly between the peronei muscles and the extensor longus digitorum. It pierces the deep fascia at the lower third of the leg on its anterior and lateral side. Before dividing into two cutaneous branches it supplies the peroneus longus and brevis muscle. The *internal dorsal cutaneous* branch passes anteriorly to the ankle joint and divides into three dorsal digital branches. The internal of these supplies the skin of the dorsum of the foot and the inner side of the great toe. The middle branch supplies the adjacent surfaces of the great and second toes. The external branch supplies the adjacent sides of the second and third toes. The *external dorsal cutaneous* branch passes along the external surface of the dorsum of the foot and supplies the adjacent sides of the third and fourth and fourth and fifth toes.

Physiology

The *tibialis anticus* muscle flexes the foot dorsally. It also aids in adduction and rotation of the foot.

The *extensor longus digitorum* extends the proximal phalanges of the four smaller toes. It aids in dorsal flexion and abduction of the foot. The *peroneus tertius* acts in conjunction with this muscle.

The *extensor proprius hallucis* extends the first phalanx of the great toe.

The *peroneus longus* muscle produces plantar flexion of the foot, lowers the inner side of the ball of the foot and turns the foot externally as the lateral border rises. This imparts a movement of abduction and rotation to the foot.

The *peroneus brevis* abducts and everts the foot.

The *extensor brevis digitorum* aids in extension of the

proximal phalanges of the first four toes.

Surgery

To expose the peroneal nerve the patient should be placed

Fig. 281. Line of incision to expose peroneal nerve.

in a semi-prone position and the leg should be slightly flexed and held in internal rotation. The incision should extend obliquely from the middle of the popliteal space along the medial border of the biceps tendon and across the fibula about an inch below its head (Fig. 281). The poplietal fascia is divided by a parallel incision to that in the skin. The nerve may then be identified beneath the edge of the biceps tendon. The nerve becomes flattened somewhat as it crosses the fibula. It is covered by a thick layer of connective tissue. Two definite fiber bundles may be seen in the peroneal as it leaves the popliteal space. Those fibers which form the anterior tibial nerve lie adjacent to the biceps tendon and consist of one or two funiculi; fibers which make up the musculocutaneous lie more lateral and dorsal and consist of three funiculi. A small artery and vein occasionally lie between these bundles.

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